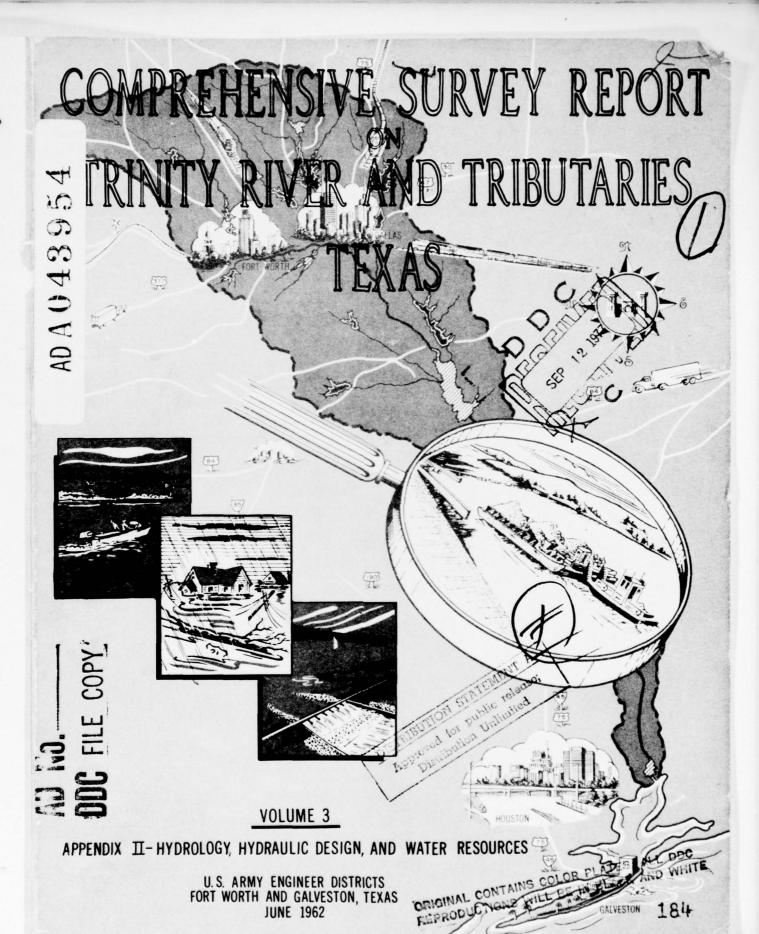
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COMPREHENSIVE SURVEY REPORT

ON

TRINITY RIVER AND TRIBUTARIES, TEXAS

Volume 3.

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APPENDIX II

HYDROLOGY, HYDRAULIC DESIGN, AND WATER RESOURCES

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U. S. ARMY ENGINEER DISTRICTS
FORT WORTH AND GALVESTON
CORPS OF ENGINEERS
FORT WORTH AND GALVESTON, TEXAS

JUNE 1962

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COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER AND TRIBUTARIES, TEXAS

This volume comprises Appendix II - Hydrology, Hydraulic Design, and Water Resources. The complete report consists of the following volumes:

Volume 1 - Main Report

Volume 2 - Appendix I - Project Formulation

Attachment - Information Required by Senate Resolution No. 148

Appendix III - Navigation and Navigation Economics

Appendix IV - Flood Control Economics

Volume 3 - Appendix II - HYDROLOGY, HYDRAULIC DESIGN, AND WATER RESOURCES

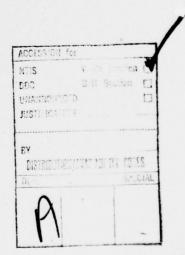
Volume 4 - Appendix VI - Cost Estimates, Geology, and Design Information

Volume 5 - Appendix V - Recreation and Fish and Wildlife

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COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER AND TRIBUTARIES, TEXAS

APPENDIX II

HYDROLOGY, HYDRAULIC DESIGN, AND WATER RESOURCES

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1 WATER RESOURCES STUDY - TRINITY RIVER BASIN, TEXAS

COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER AND TRIBUTARIES, TEXAS

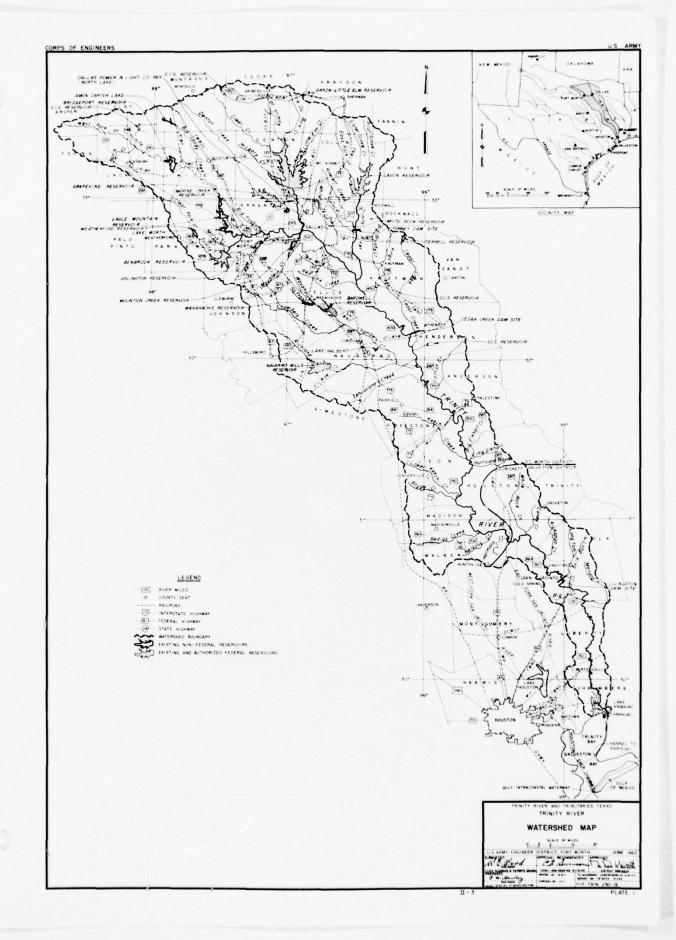
APPENDIX II HYDROLOGY, HYDRAULIC DESIGN AND WATER RESOURCES

GENERAL

- 1. SCOPE. This appendix contains detailed hydrologic, hydraulic design, and water resource data pertinent to formulation of the comprehensive plan of improvement for the Trinity River Basin and provides a basis for statements relating to the above subject matter that are presented in other sections of this report. The Department of Health, Education, and Welfare, Public Health Service, studied the Trinity River Basin as requested by the Corps of Engineers, Fort Worth District - by letter dated June 8, 1959, to determine the present and prospective municipal and industrial and water quality control requirements which were adopted for this report. The request for this study was made in accordance with a Memorandum of Agreement between the Department of Health, Education, and Welfare and the Department of the Army, dated November 4, 1958, pertaining to the Water Supply Act of 1958, Title III of Public Law 85-500. Their report, "Water Resources Study, Trinity River Basin, Texas," is included in this appendix as exhibit 1. Certain data in this appendix were obtained from "A Report to the President and to the Congress," prepared by the U. S. Study Commission - Texas.
- 2. RELATIONSHIP OF THIS APPENDIX TO OTHER PARTS OF THE REPORT.-This appendix presents a detailed analysis concerning all hydrologic aspects of water problems in the basin, including floods, droughts, water quality and similar hydrologic considerations. The magnitude and frequency of floods are developed, stream flow data are presented, and yields are estimated. The demand for water supply is given for all uses, including navigation, and evaluations are made as to how these needs can be met from projects considered in connection with this study. Details concerning hydrologic and hydraulic design of all structures considered in this study are covered herein, including the design for locks and dams. Hydrologic data developed herein on floods with and without various projects have been used in Appendix IV on Flood Control Economics as a basis for evaluating project flood control benefits. The hydrologic and hydraulic design data presented herein, as well as similar data prepared for other projects that were studied but not recommended for authorization at this time, have been used in the formulation processes covered in Appendix I. The estimates of future needs of water for various uses presented herein are consistent and within the parameters of economic projections presented in the economic base survey, Appendix VII.

II-1

3. DESCRIPTION OF THE BASIN. The Trinity River Basin lies in the eastern half of the State of Texas, approximately between 29°46' and 33°44' north latitude and 94°40' and 98°43' west longitude. It is bounded on the north by the Red River Basin; on the east by the Sabine and Neches River Basins; and on the west and south by the Brazos and San Jacinto River Basins. The Trinity River Basin is relatively long and narrow with a maximum length of about 360 miles and a maximum width of about 100 miles near the upper end. The basin, having a total drainage area of 17,845 square miles, is shown on plate 1. It embraces all or portions of 38 counties and lies within two physiographic provinces - the northwestern portion of the basin is situated in the central lowland province of the Interior Plains and the remainder of the basin is in the West Gulf Coastal Plain. The topography of the basin is that of a moderately to gently sloping plain which has been more or less dissected by streams.

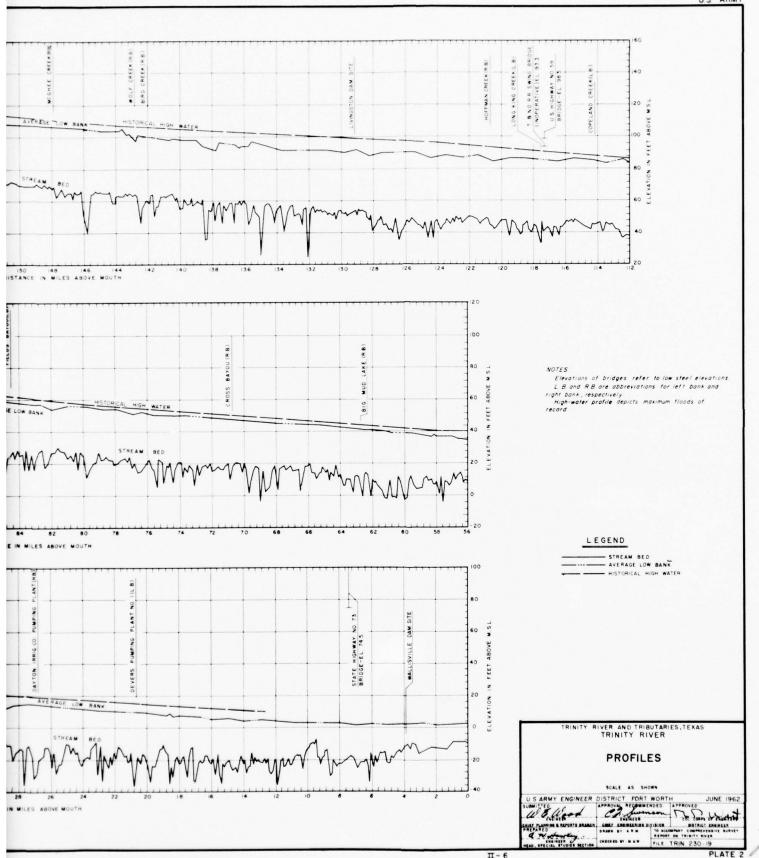


- 4. The Coastal Plain section, which extends nearly to Fort Worth on the main stream and includes the entire East Fork watershed, has a generally flat or undulating to gently rolling topography on the interstream divides. In the vicinity of the larger streams the topography is more rolling and broken, but nowhere does it present a rugged appearance.
- 5. The Central Lowland province, which includes the watersheds of the West Fork and Elm Fork, has considerable areas of flat to undulating land on the interstream divides, but the topography is generally more rolling and broken. Approaching the headwaters of the West Fork the topography, especially near the streams, becomes quite rugged.
- 6. The general land elevation of the basin rises gradually from a few feet above sea level at Galveston Bay to about 550 feet on the interstream divides in the vicinity of Dallas, and to about 800 or 850 feet on the divide at the headwaters of Richland Creek and East Fork. To the west and north of Dallas the general slope of the land increases, the elevation rising to about 1,250 feet on the divide in the northwest corner of the basin.
- 7. Table 1 lists the principal tributaries and sub-tributaries of the Trinity River system and gives the length and contributing drainage area of each. Plates 2 through 5 show the historical highwater, average bank, flood stage, and streambed profiles of the Trinity River. Plates 6 through 12 show the historical highwater, average bank, and streambed profiles for the principal tributaries of the Trinity River. Plates 2 through 12 also show the location of existing reservoir projects and damsites of the projects included in the proposed plan of improvement. The drainage areas for the various watersheds and sub-watersheds in the Trinity River Basin are shown on plates 38 and 39.

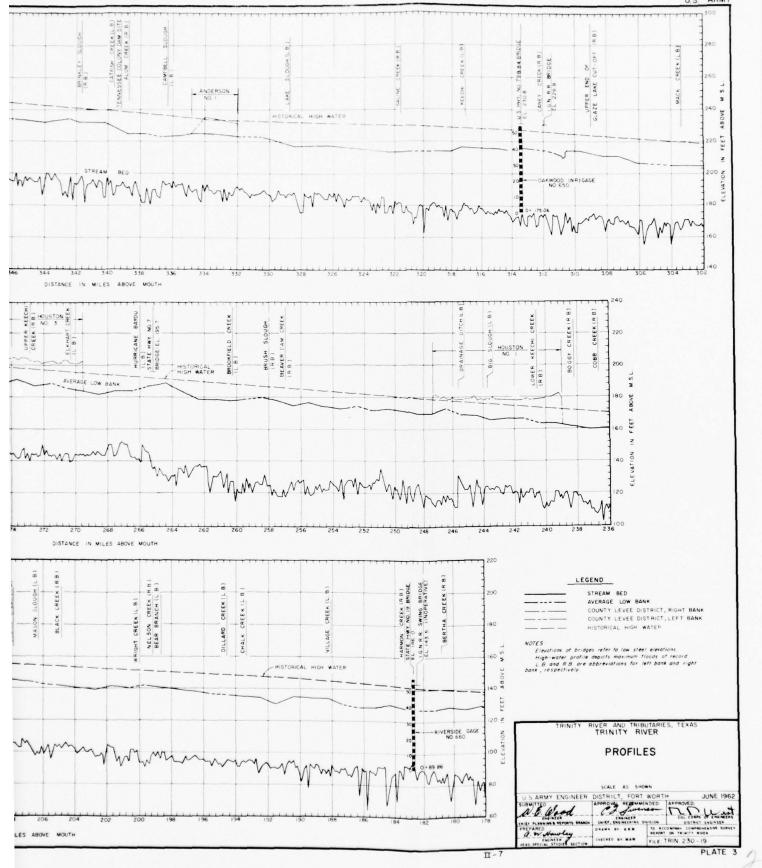
TABLE 1
PRINCIPAL STREAMS
TRINITY RIVER BASIN

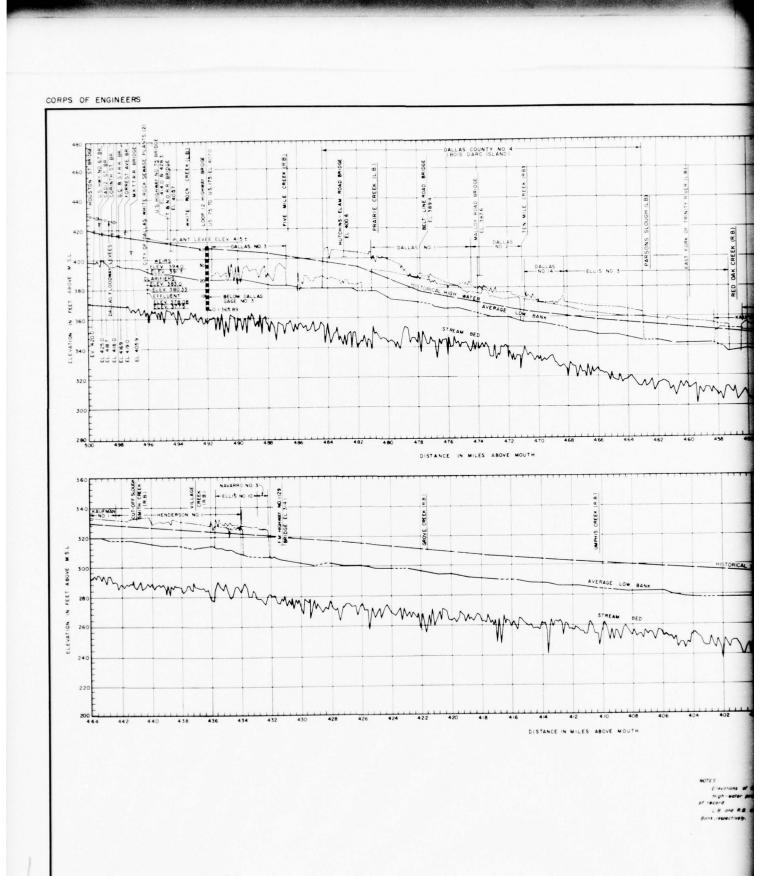
Stream	confluence with parent stream (miles above mout	:(river :	Drainage area (sq. mi.)
·	Timites above mone	m).mrres/(r).	(sq. mi.
rinity River (including			
West Fork)	0	715	17,845
Clear Fork of Trinity River	558.7	70	531
Big Fossil Creek	542.7	21	75
Village Creek	533.8	33	184
Mountain Creek	507.8	37	305
Elm Fork of Trinity River	505.5	119	2,578
Denton Creek	18.4	102	719
Little Elm Creek	39.4	41	262
Clear Creek	50.5	55	354
White Rock Creek (Collin a	nd		
Dallas Counties)	493.1	42	138
East Fork of Trinity River	459.8	112	1,309
Duck Creek	31.0	22	45
Cedar Creek	385.5	92	1,072
Richland Creek	372.4	97	1,990
Chambers Creek	14.2	107	1,072
Tehuacana Creek	347.2	42	432
Catfish Creek	339.6	37	305
Upper Keechi Creek	272.8	40	512
Lower Keechi Creek	240.5	29	192
Bedias Creek	207.9	35	603
White Rock Creek (Houston	and		
Trinity Counties)	169.9	35	518
Long King Creek	117.5	31	214

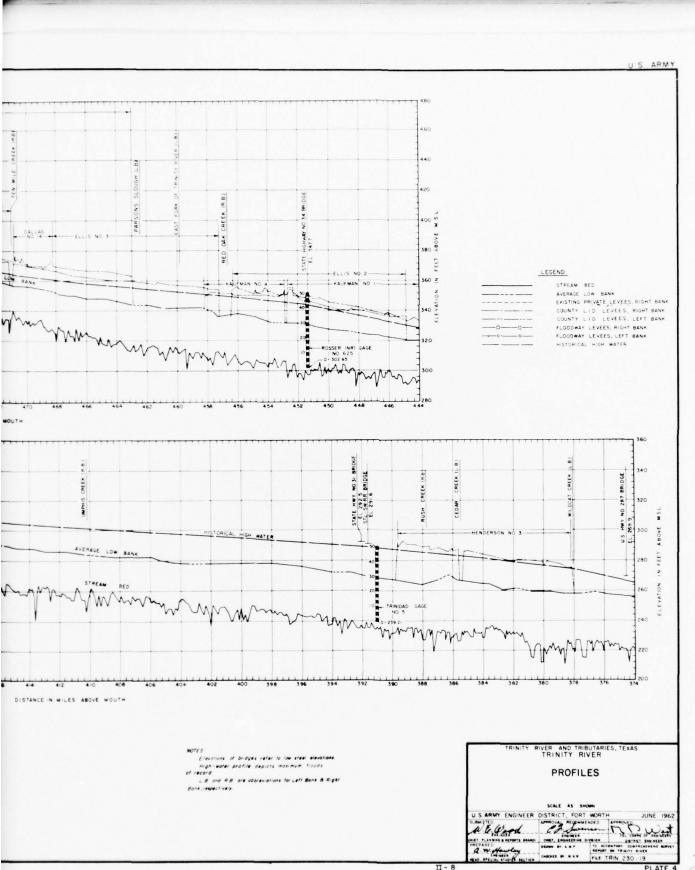
⁽¹⁾ Existing conditions.

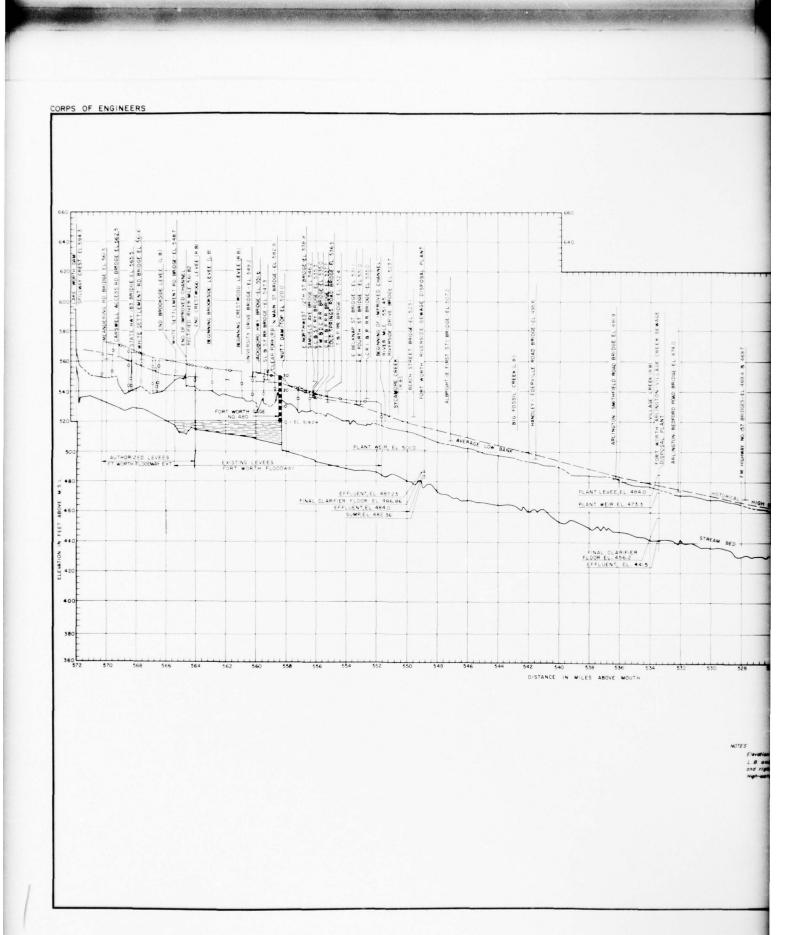


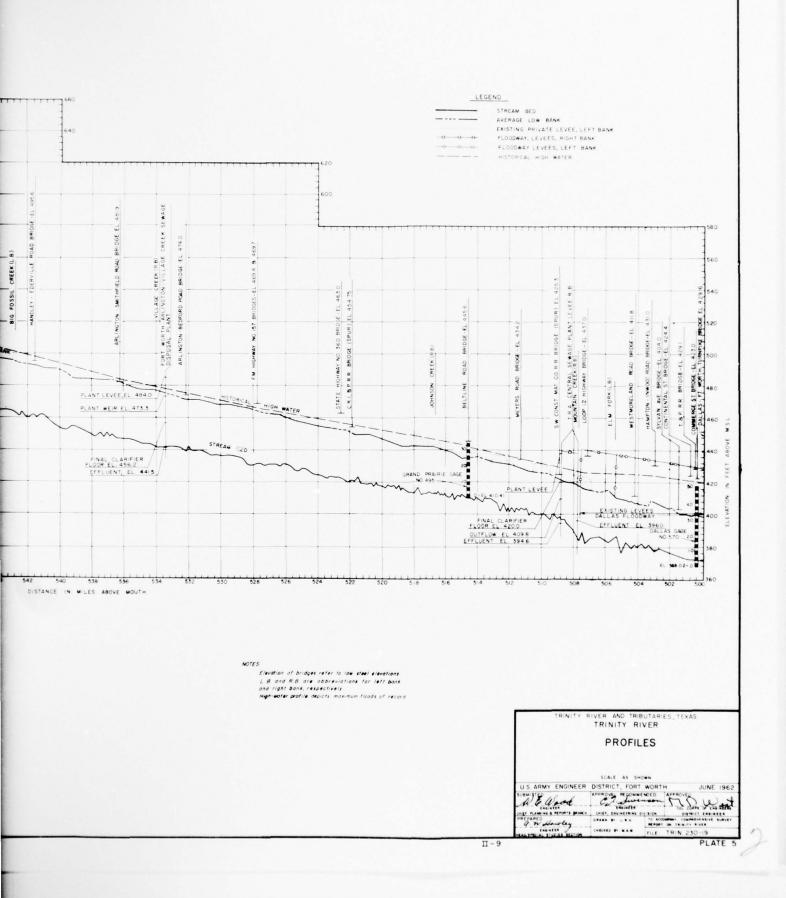


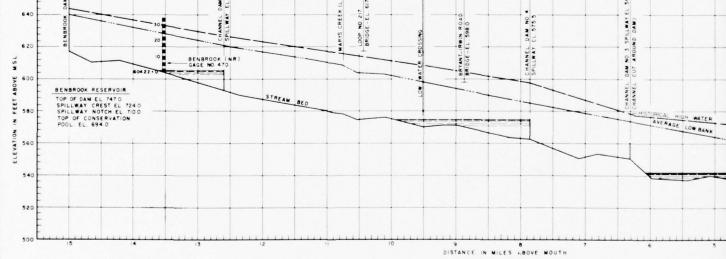


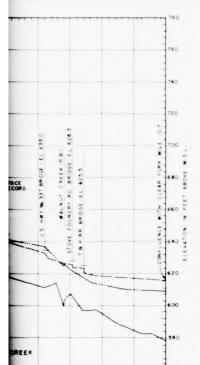












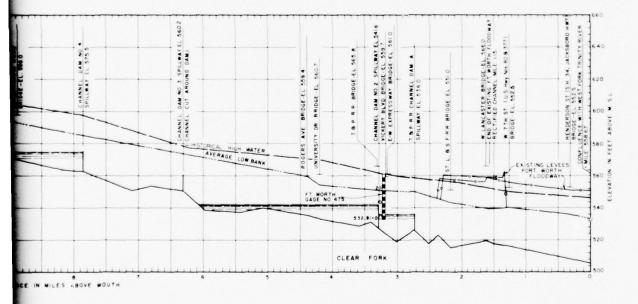
NOTES

NOTES.

Elevations of bridges refer to law steel elevations.

High water profile depicts maximum floods of record.

L.B. and R.B. are abbreviations for left bank and right bank, respectively.



LEGEND

STREAM BED TRINITY RIVER AND TRIBUTARIES, TEXAS
CLEAR FORK TRINITY RIVER AND MARYS CREEK

PROFILES

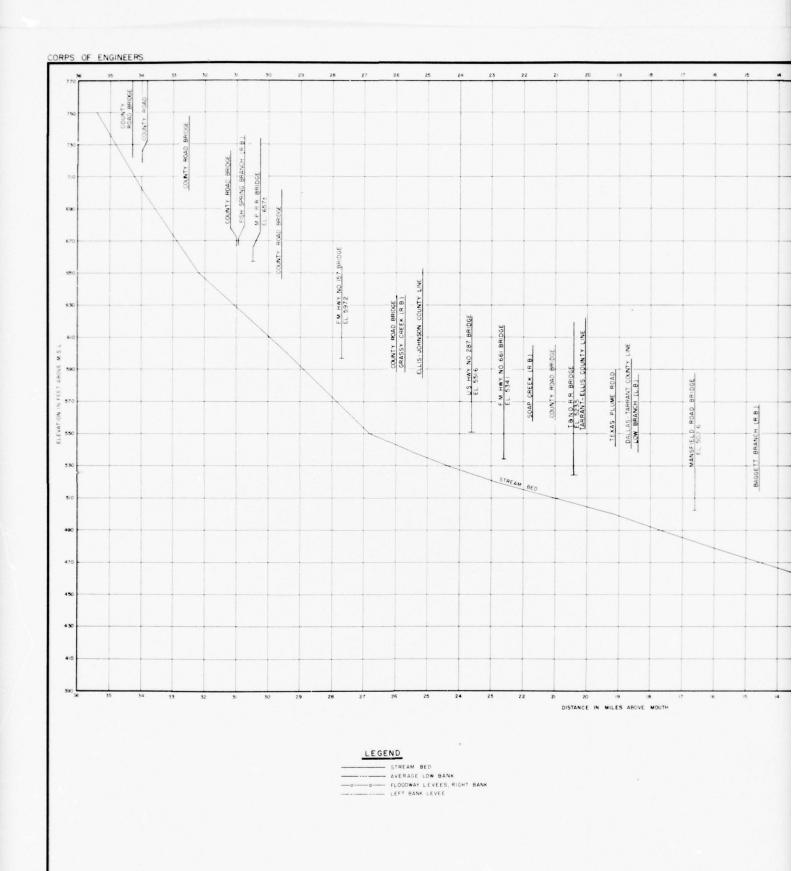
SCALE AS SHOWN

US ARMY ENGINEER DISTRICT, FORT WORTH JUNE 1962

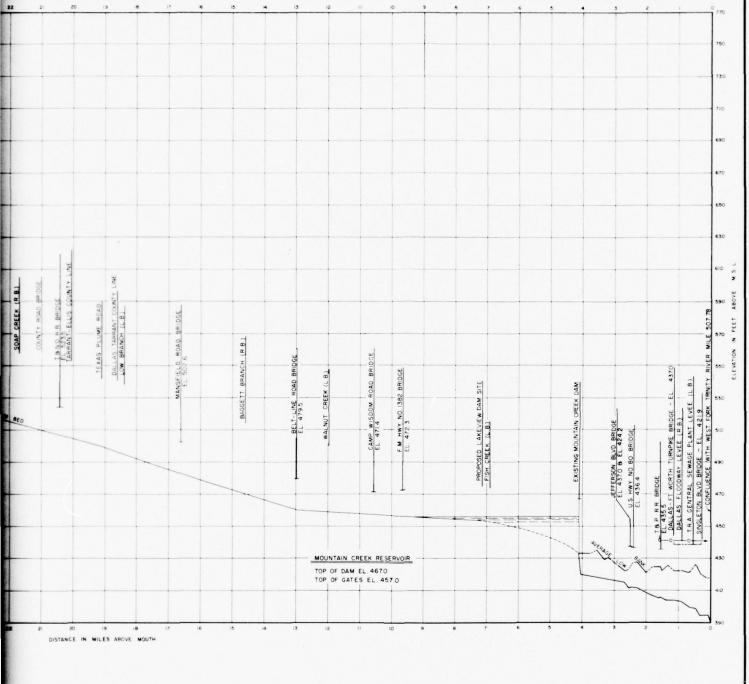
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Bridge elevations refer
to low steel elevations
LB and RB are abbreviation
for left bank and right bank, respectively.

TRINITY RIVER AND TRIBUTARIES, TEXAS MOUNTAIN CREEK

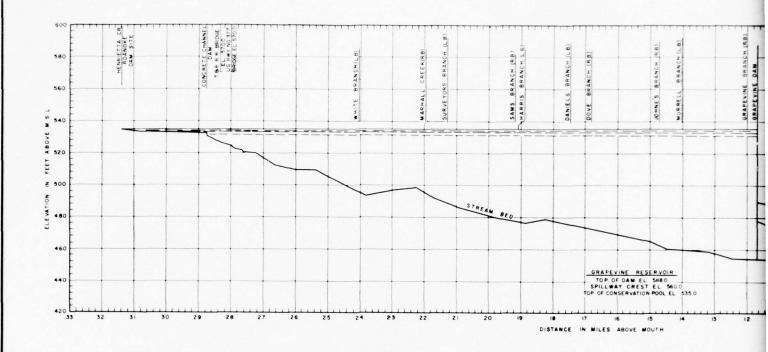
PROFILES

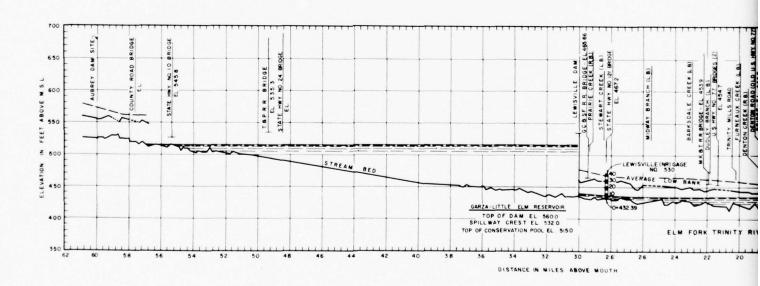
W. E. Wood ENGINEER
CHIEF, PLANNING & MEPORTI
PREPARED

W Hawley
ENGINEER
HEAD, SPECIAL STUDIES S

U.S. ARMY ENGINEER DISTRICT, FORT WORTH JUNE 1962

W.G. Board Arrender Brown Fred House Control Contro





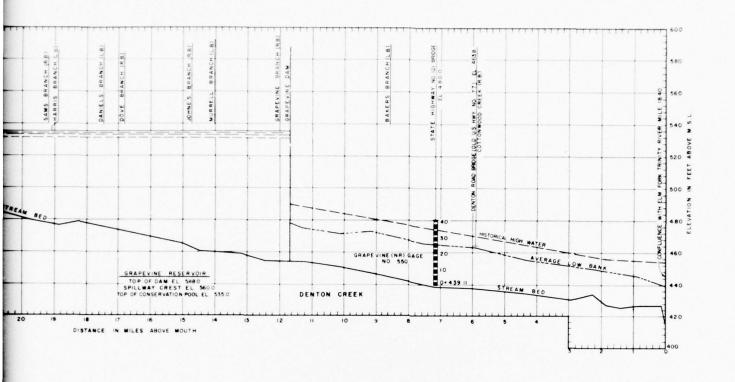
LEGEND

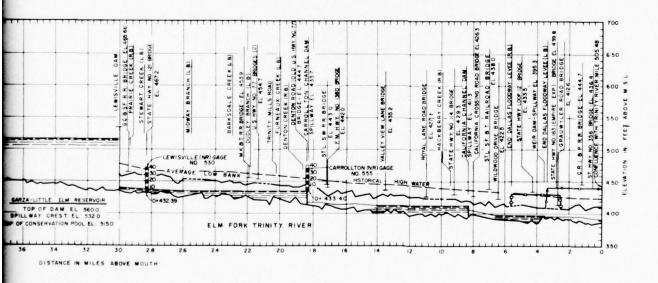
STREAM BED

--- AVERAGE LOW BANK

FLOODWAY LEVEES, RIGHT BANK

- HISTORICAL HIGH WATER





LEGEND

STREAM BED AVERAGE LOW BANK --- FLOODWAY LEVEES, RIGHT BANK - FLOODWAY LEVEES, LEFT BANK - - HISTORICAL HIGH WATER

NOTES

Elevations of bridges refer to low steel elevations

L.B. and R.B. are abbreviation for left bank and right bank, respectively.

High-water profile depicts maximum floods of record.

TRINITY RIVER AND TRIBUTARIES, TEXAS ELM FORK AND DENTON CREEK PROFILES

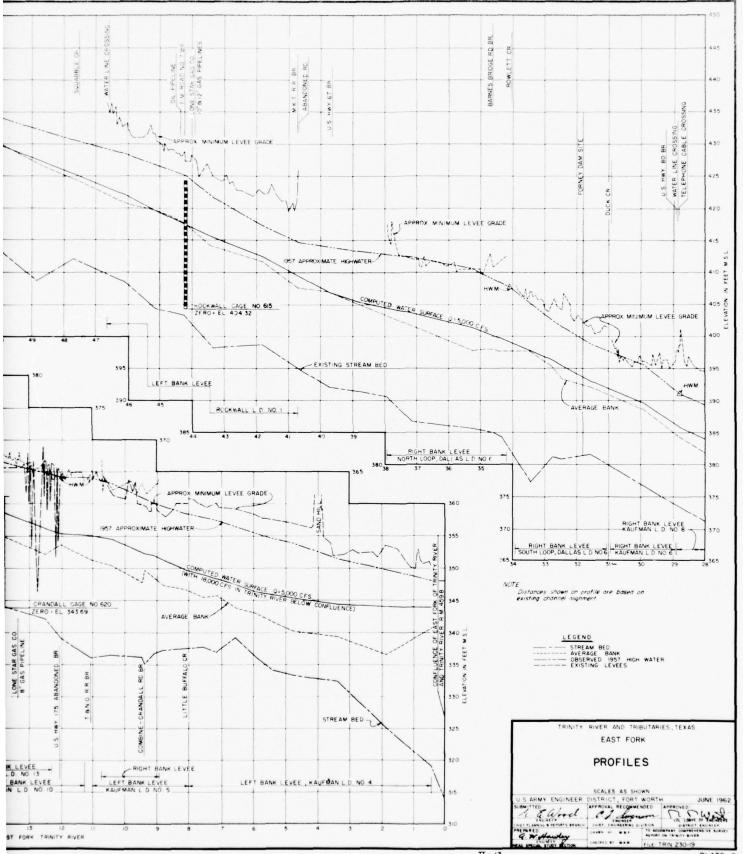
US ARMY ENGINEER DISTRICT, FORT WORTH

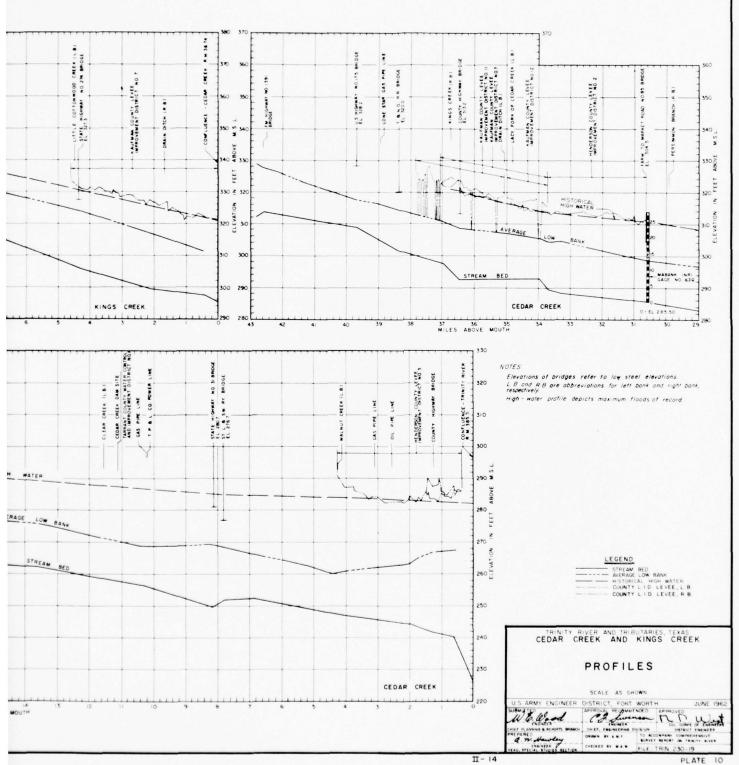
US ARMY ENGINEER DISTRICT, FORT WORTH

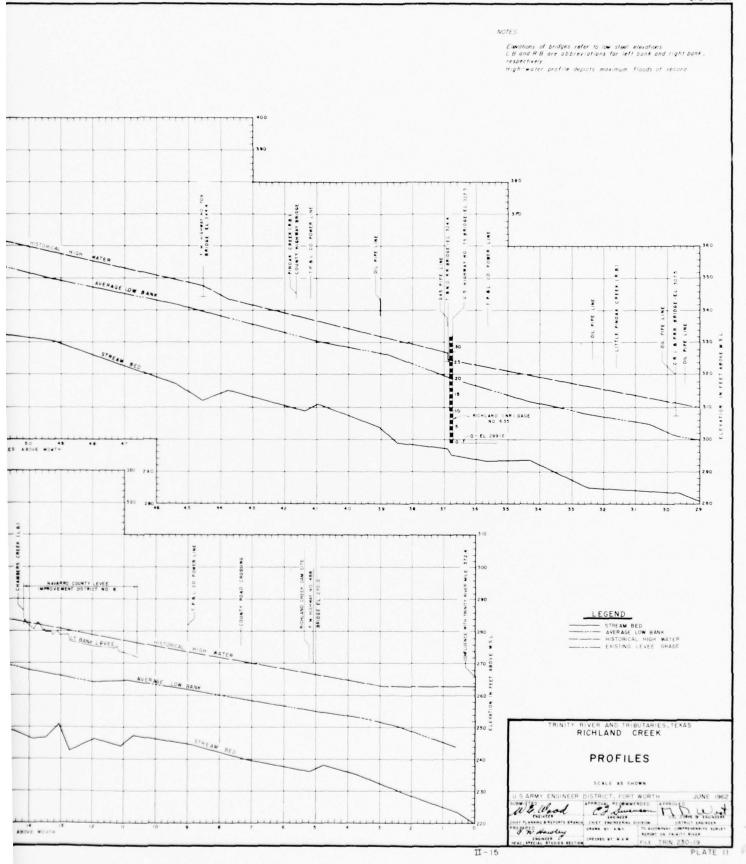
US ARMY ENGINEER DISTRICT, FORT WORTH

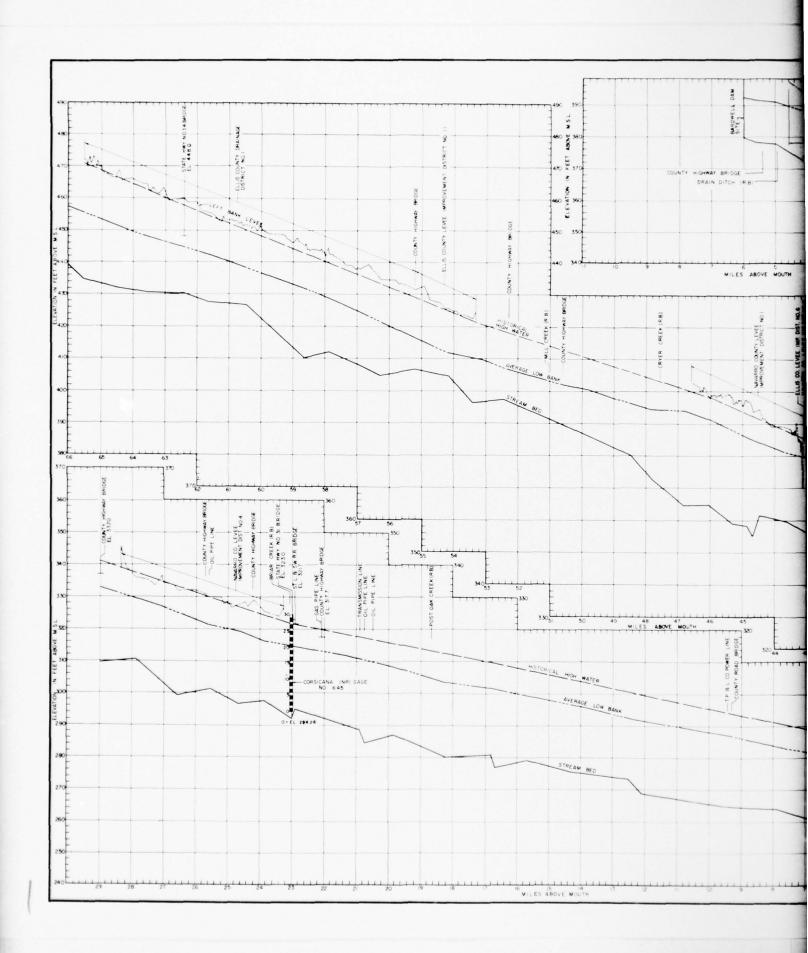
JUNE 1962

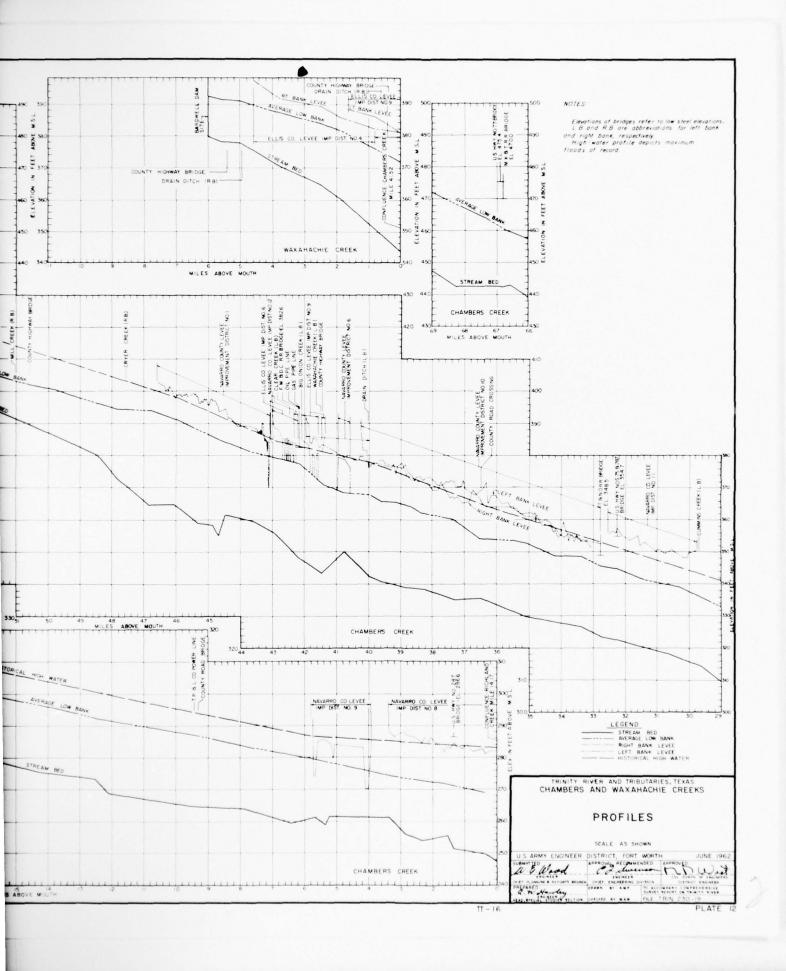
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8. EXISTING FEDERAL IMPROVEMENTS. - There are at present four Corps of Engineers flood-control reservoirs in operation in the Trinity River Basin. An additional Corps of Engineers flood-control reservoir is under construction; one has been authorized; another has been recommended; and enlargement of one of the existing reservoirs, together with improvement of its downstream channel and levees, has been recommended. The Corps of Engineers also has two existing floodway projects, one authorized and one previously recommended project providing for extension of an existing floodway, and one authorized local protection project in the basin. In addition to the above projects, the Corps of Engineers has authorization for construction of a navigation channel to Liberty and a reservoir project near the mouth of the Trinity River has been recommended for authorization for salinity control, navigation, and other water resource purposes. The lower portion of the authorized navigation channel to Liberty has been completed to the vicinity of Anahuac. A list of federal projects showing their present status is presented in the following tabulation:

Project

Benbrook Reservoir
Grapevine Reservoir
Garza-Little Elm Reservoir (Lewisville Dam)
Lavon Reservoir
Navarro Mills Reservoir
Bardwell Reservoir
Wallisville Reservoir
Lavon Reservoir Enlargement and Channel
Improvement
Fort Worth Floodway
Dallas Floodway
Fort Worth Floodway Extension, Part I
Fort Worth Floodway Extension, Part II
Big Fossil Creek Local Flood Protection
Navigation Project to Liberty

Status

In operation
In operation
In operation
In operation
Under construction
Authorized
Previously recommended

Previously recommended In operation In operation Authorized Previously recommended Authorized Authorized to Liberty. Completed to vicinity of Anahuac

Pertinent data for the existing and authorized projects are shown in tables 2 and 3. Pertinent data for the previously recommended floodway project at Fort Worth are shown in table 14, and those for the previously recommended reservoir projects are shown in table 16. Data for the authorized navigation project to Liberty are not included in these tables. The navigation project to Liberty was authorized for a 9-foot depth and 150-foot bottom width from the Houston Ship Channel to Liberty, approximate river mile 40. A portion of the channel, to about 1 mile downstream from Anahuac, has been completed. The location of each of the above projects is shown on plate 13.

TABLE 2

PERTINENT DATA - EXISTING & AUTHORIZED CORPS OF ENGINEERS RESERVOIRS

		: :Contrib.:	rib.:	Ne	Net storage	- acre-feet		Total con-			Pertinent elevations - ft. m.s.1	elevations	1 - ft. m.6	.1.
Reservoir	: Stream	Stream :River: D.A. :mile:(sq.m.	. is:	Sediment reserve in Cons.pool:FC pool	Serve in:			:trolled storage: Yield :Stream-!Pop con-: Top FL: Design water: Top of (acre-feet) : c.f.s.; bed :servation:Control: surface : dam	rage: Yiel	e: Yield :Stream	-fop con-	:fop con- :Top FI.: servation:Control:	Design water	er:Top of : dam
Benbrook	Clear Fork	15 4	433	15,750	0	72,500	170,350*	258,600*	10.0	0.710 0	0.469	710.0*	741.0	747.0
Grapevine	Denton Cr.	11.7	769	27,300	8,700	161,250	238,250	435,500	,	0.151.0	535.0	260.0	581.0	588.0
Garza-Little Elm Elm Fork	n Elm Fork	30.0 1,6	1,658	000,94	0	7,36,000		1,002,900		0 435.0	515.0	532.0	553.0	560.0
Lavon	East Fork	55.9	1111	43,600	4,200	100,000	275,600	423,400		0 433.0	472.0	0.064	0.961	505.0
Naverro Mills	Richland Cr. 63.9		316	10,100	5,700	53,200	143,200	212,200		375.3	3 424.5	143.0	451.9	457.0
Bardwell	Waxahachie Cr.6.0		171	000'9	2,700	29,500	009,67	117,800		379.8	3 418.0	0.489.0	143.7	447.5
	. Spt.	Spillway design	£100d			Spillvey		: Floo	Flood-control outlet works	outlet wo	rks :	Į.	Low-flow outlets	ets
Reservoir	: Peak infl	ow : Peak out	flow:	Volume	: Net length at	gth at :	Control	. No. 8. c470.	lon two		: Intake :	No. & ata	. 4	Intake
				מרוב-ופבר	1 76517	. / / / .		יווסים סידערי		1	מור פובייי	110. 8 977	,	o eter.
Benbrook	290,100	180,000	8	483,800	2004		None	1-13.0	2-6.5'x13'gates	gates	622.0	2-30"	9	0.959
Grapevine	319,400	190,700	8	797,800	200		None	1-13.6	2-6.5'x13'gates	gates	0.274	2-30.0	55	500.5
Garza-Little Elm	m 633,200	229,400		1,815,000	94		None	1-16.0	3-6.5'x13'gates	gates	0.844	2-60"\$	3	0.184
Lavon	430,300	255,800	8	007,096	084		12-40'x28'gates	None				5-36" sluices		453.0
Navarro Mills	280,500	225,000	8	52,100	240		6-40'x29'gates	None				2-36" \$	7	0.004

* The spillway consists of a 100-foot section with crest at elevation 7.0.0 and an additional 400-foot weir with crest at elevation 724.0. The total flood-control storage provided below elevation 724.0 is 170,350 acre-feet, of which 76,550 acre-feet lies below elevation 710.0. The discharge through the 100-foot notch with the pool at elevation 724.0 is 17,300 efs.

NOTE: Figures shown parenthetically in yield column are existing yields in million gallons daily.

4-40'x28'gates None

160

274,400

115,700

159,300

Bardwell

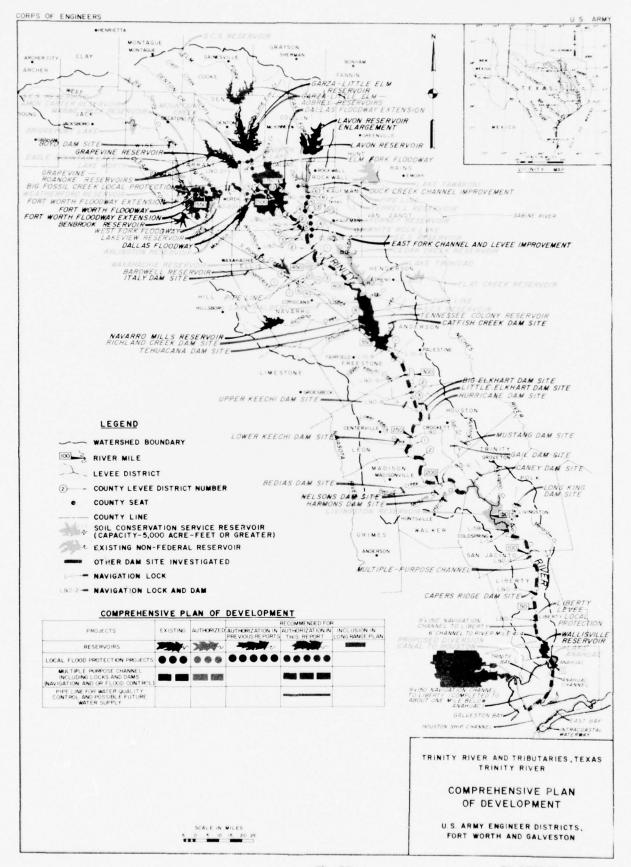
405.0

1-36" sluice

TABLE 3

ERS
ENGINE
OF
CORPS
BY
) PROJECTS
(FLOODWAY)
EXISTING LOCAL IMPROVEMENT (FLOODWAY) PROJECTS BY CORPS OF ENCINEER
LOCAL
EXISTING
1
DATA
PERTINENT DATA

Project Local agency Stream Project Stream Stream Project Stream S				: Drain	Drainage area at head of	nd of	: River mile		: Improved : Design : Min. :	: Design	: Win:		Length of levee	
West Fork above	Project	: Local agency	: Stream	: Total :C	dect - square mi	trolle	7	s of :	channel length	: flood,	:free-:	Left:	Right bank	
West Fork above 2,088 1,974 114 558.7 to 564.7 16,373' 50,000 Clear Fork					FORT WORTH									
Clear Fork 531 433 98 0.0 to 1.6 6,070' 75,000	Fort Worth Floodway		West Fork above Clear Fork	2,088	1,974	114	558.7 tc	564.7	16,373'	50,000	4	6,662	15,045'	
West Fork below 2,627 2,407 220 551.3 to 558.7 30,050' 95,000			Clear Fork	531	433	98	0.0 to	1.6	6,070	75,000	.71	8,300	0	
West Fork			West Fork below Clear Fork	2,627	2,407	220	551.3 to	558.7	30,050	95,000	. 7	14,965'	20,100	
Creek	Fort Worth Floodway-Part I	Tarrant County W.C.&I.D. No. 1	West Fork	2,070	1,974	8	564.7 to	, 570.4	22,300	50,000	-7	11,280'	30,840	
Dallas County Flood West Fork - Control District Trinity River 3,502 2,407 1,095 505.48 to 508.7 0 195,000 Elm Fork - Trinity River 2,578 2,352 226 0.0 to 3.5 0 61,000 Trinity River 6,080 4,759 1,321 497.37 to 505.48 28,700' 226,000	Big Fossil Creek Floodway	City of Richland Hills	Big Fossil Creek	53	0	53	0.0 to	3.33	17,500'	52,000	.5	6,700'	0	
Dellas County Flood West Fork - Control District Trinity River 3,502 2,407 1,095 505.48 to 508.7 0 195,000 Elm Fork - Trinity River 2,578 2,352 226 0.0 to 3.5 0 61,000 Trinity River 6,080 4,759 1,321 497.37 to 505.48 28,700' 226,000					DALLAS									
2,578 2,352 226 0.0 to 3.5 0 61,000 6,080 4,759 1,321 497.37 to 505.48 28,700' 226,000	Dallas Floodway	Dallas County Flood Control District		3,502		\$60,	505.48 t	508.7	0	195,000	.7	0	18,700'	
6,080 4,759 1,321 497.37 to 505.48 28,700' 226,000			Elm Fork - Trinity River	2,578	2,352	5256	0.0	3.5		61,000	·	20,278'	0	
			Trinity River	6,080		,321	497.37 to	505.48		226,000	• 7	42,300	38,800'	



- 9. The Soil Conservation Service, Department of Agriculture, has been authorized by Congress to undertake a program of runoff and water-flow retardation and soil erosion prevention in the Trinity River Basin. As of 1961 a total of 288 detention structures had been constructed in the basin as part of this program. Data on the complete program and its effect are presented later in this appendix (paragraphs 69, 94, 95, and 135).
- 10. EXISTING NON-FEDERAL IMPROVEMENTS. There are 18 non-federal reservoirs existing or proposed for immediate construction in the Trinity River Basin with an individual capacity greater than 5,000 acre-feet and 79 that have a capacity of less than 5,000 acre-feet each. These reservoirs are principally for municipal and industrial water supply and for non-consumptive cooling purposes at power generating plants. Marine Creek Reservoir, constructed by the Tarrant County Water Control and Improvement District No. 1, is the only non-federal reservoir with over 5,000 acre-feet capacity that contains allocated flood-control storage. Of the 15,400 acre-feet of storage in the reservoir, 11,600 acre-feet are reserved for flood control. Other pertinent information on the 18 reservoirs is listed in downstream order in table 4. The reservoirs are shown on plate 13.

PERTINENT DATA - EXISTING NON-FEDERAL RESERVOIRS WITH CAPACITIES GREATER THAN 5,000 ACRE-FEET

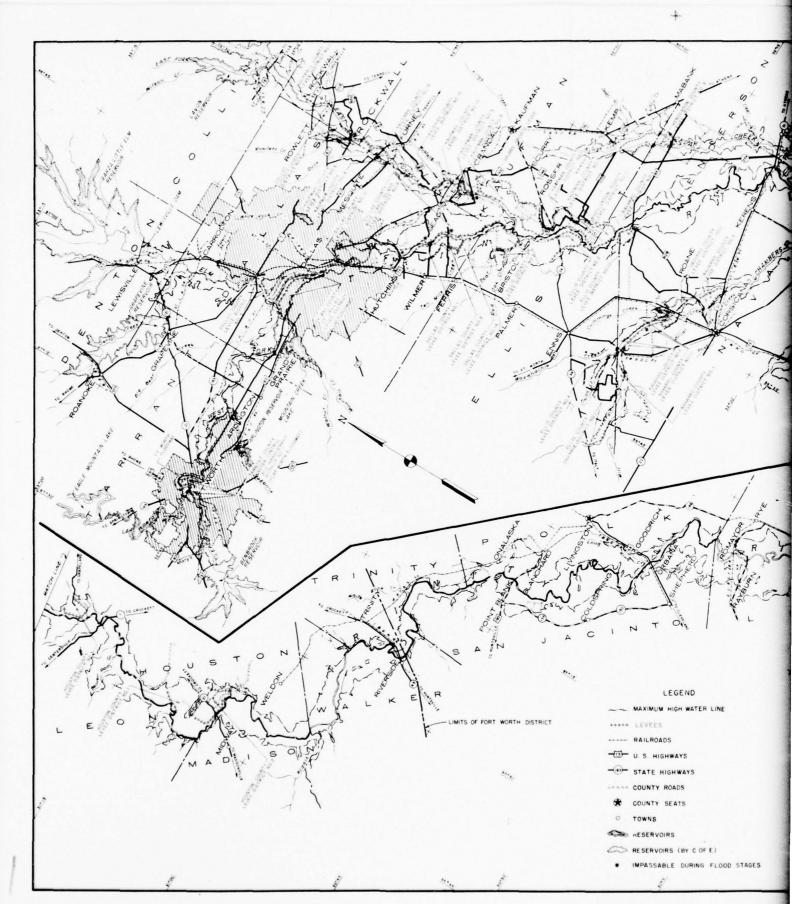
		: Location : Contrib. : Storage capacity - acre-feet : Reservoir	-	Contrib.	Storag	Storage capacity -	acre-feet	et	:Reservoir elev.:		. 2020
Мете	: Ownership	Stream	River	D.A. :	Sediment:	: D.A. : : Flood : : Flood : : flood : : flood : : Sediment: Conservation: Control:	: Flood :	Total	:at maximum con-: Year :trolled storage:Constructed	Year	
Amon Carter	City of Bowle	Big Sandy Creek	31.0	103	5,100	14,800	0	19,900	980.0	1956	00
Bridgeport	Tarrant County WC&ID #1	West Fork Trinity	626.2	411,1	37,700	233,200	0	270,900	. 826.0	1932	787
Eagle Mountain	Tarrent County WC&ID #1	West Fork Trinity	583.3	1,974	39,100	143,500	0	182,600	0.649	1934	
Lake Worth	City of Fort Worth	West Fork Trinity	572.1	5,069	2,100	31,600	0	33,700	594.3	1913) (17.5)
Marine Creek	Tarrant County WC&ID #1	Marine Creek	J.4	10	1450	3,350	11,600	15,400	715.0	1957	00
Weatherford	City of Weatherford	Clear Fork Trinity	39.8	106	6,300	13,100	0	19,400	996.0	1956	240
Arlington	City of Arlington	Village Creek	8.0	136	10,100	35,600	0	45,700	550.0	1957	50 4
Mountain Creek	Dallas Power & Light Co.	Mountain Creek	4.1	589	20,000	7,200	0	24,200	0.724	1936	000
North Lake	Dallas Power & Light Co.	South Fork - Grapevine Creek	0.5	2.3	1,100	16,000	0	17,100	510.0	1957	600
White Rock	City of Dallas	White Rock Creek	12.0	8:	7,400	006,4	0	12,300	457.5	1911	3
Trinided	Texas Power & Light Co.	(2)	•	•	0	6,200	0	6,200	285.0	1925	(0)
Livingston (3)	City of Houston and the Trinity River Authority	Trinity River	129.2	909'91	51,600	1,698,400	0	1,750,000	131.0	(3)	1950 (4)
Anahusc	Chambers and Liberty Counties Navigation Dist.	(5)	•	129	0	35,300	0	35,300		1953	(13.4)
Forney (3)	City of Dallas	East Fork Trinity	31.8	1,074	24,000	000,994	0	000,064	434.5	(3)	91 (58.8)
Terrell	City of Terrell	Muddy Cedar Creek	8.6	13	1,200	7,100	0	8,300	503.0	1956	(0.6
Cedar Creek (3)	Tarrant County WC&ID #1	Cedar Creek	11.11	1,013	20,900	909,000	0	678,900	322.0	(3)	268 (173.2)
Waxabachie	Ellis County WID No. 1	South Prong - Waxahachie Creek	0.5	ਖ਼	2,100	11,400	0	13,500	531.5	1957	(1.9)
Halbert	City of Corsicans	Elm Creek	0.7	12	1,170	6,250	0	7,420		1924	(0)

11-22

(1) Operating level of reservoir between elevations 450.0 and 457.0.
(2) Off-channel reservoir, on left bank of Trinity River just upstream from mouth of Cedar Creek.
(3) Under construction.
(4) Combined yield from Livingston and Wallisville Reservoirs operated as a system including return flows. See table 16 for other pertinent data on Wallisville Reservoir.
(5) Off-channel reservoir - Turtle Bay.
NOTE: Where no yield is indicated for 2020 conditions some yield would be available for a portion of the critical period.

Figures shown parenthetically in yield column are 2020 yields in million gallons daily.

11. The 40 organized levee improvement districts in the Trinity River Basin that are active have approximately 341 miles of levees. The levees provide varying degrees of protection to about 180,500 acres of land along the Trinity River and its tributaries. The districts are shown on plate 14, and pertinent data concerning them is listed in table 5. Levees of the Tarrant County Water Control and Improvement District No. 1 and levees of the City and County of Dallas Levee Improvement District have been incorporated in the Corps of Engineers Fort Worth Floodway and Dallas Floodway projects.



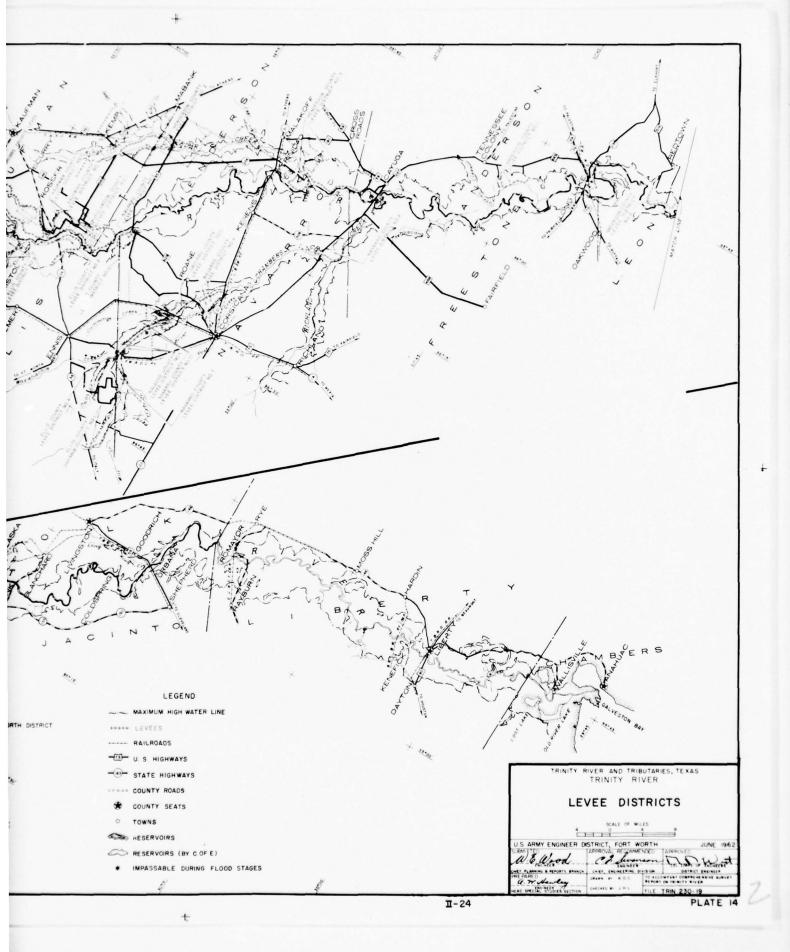


TABLE 5

								LEVEE DA		
Property forms and May 1870 1871 1	Levee Improve County	Dist. No.	Stream	Веля	Rive: From	r mile To		at age	protected	Neanrick
		1	West Fork	RAL	0.0 551.7	2.3 565.4	12.31	25	1,710	Overtopped by 1949 flood. Repaired by CofE. Strengthened by CofE 1950-1957. (1) Tarmit County Water Control & Improvement District No. 1 (Form worth)
Section 1	allas(2)		Trinity River and West Fork	RAL	498.0 505.5	505.5 509.0	14-33	52	9,520	Never overtopped. Repaired 1945-1946 by CofE; strengthened by CofE 1950-1959. (2) City and County of Dallas L.I.D. (Dallas)
1	allas	5	Trinity River and Kim Fork	RAL	498.0	505.5 5.6	14.61	52	5,000	Northwest overtopped in 1942, repaired by Doff in 1948. Strengthened by Doff 1950-1959. (Dallas)
	allas	12	Trinity River	L	496.0	196.2	0.20	47	59	Sandbagged low areas in 1949 flood- (Dallas)
	allas	3	Trinity River	В	486.8	.,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	9.75		(3,650)•	Levee never completed.
Controlled	allas	1	Trinity River	В	474.4	481.0	9.58	45	3,366	Overtopped by 1942 and 1949 floods. Repaired by Coff after 1949 and 1957 floods. Local interest raised levee 1958. (Dallas)
	allas	2	Trinity River and Cottonwood Creek	R	471.1	474.4	9.00	45	2,080	Overtopped by 1935 and 1942 floods. Repaired by local interests. Overtopped by 1949 and 1957 floods. Repaired 1944, 1948, 1949, 1957 & 1998 by Coff. (ballas)
15		14	Trinity River and Ten Mile Creek	В	468.3	471.0	5.18	45	2,400	Overtopped by 1935 and 1942 floods. Repaired by local interests. Repaired by Ocff 1945. Overtopped by few Mile Creek 1946 and 1949 - no damage, levee raised by local interests. (ballas)
1	allas ⁽³⁾	*	Trinity River	L	463.0	484.4	16.08	48	17,700	Never overtopped. Repaired 1948 by Coff. (3) Dallas County Bois D'Are Island L.I.D. No. 4. (Dallas)
Printy New Part West W	llis	3	Trinity River and Red Oak Creek	В	457-3	468.3	15.04	47	8,229	Overtopped by 1942 flood. Repaired by local interests. Repaired by CofE 1946. Overtopped by Red Cas Creek 1998, repaired by CofE 1999-1960. (Dallas)
	lis	2	Trinity River	В	144.9	456.3	16.80	40	11,100	
	eufsen	1	Trinity River	L	442.4	452.8	6.78	50	7,380	Duraged by 1942 flood. Repaired by local interests. Duraged 1945. Repaired by Cofe 1945-1948. (Nonser)
	nderson	1	Trinity River	L	433.9	442,4	10,12	40	4,216	
Printry New L	lis and Navarro	10 3	Trinity River	R	432.8 432.2	435.6 432.8	4-17	42	1,840	Never overtopped (Hosser)
1	enderson	3	Trinity River and Cedar Creek	L	378.3	389.6	28.26	47	17,000	Overtopped by 1942 and 1945 floods. Repaired by Coff. (Triniday, Mabank)
Notice 1	nderson	1		Ĺ	332 - 9		5.53		2,593	Overtopped by 1942 and 1945 floods. Repaired by Coff 1944-1945. (Long Lake)
Name	nderson	2	Trinity River	L	284.8	294.4	6.90	48	5,740	Repaired by local interests 1951. Overtopped by 1957 flood. Repaired by local interests. Overtopped by 1958 flood. Repaired by Coff. Local interests reised grade of levee. (Long laxe)
Printing Name	Naton	3	Trinity River	L	269.6	275.0	10.03	52	5,140	
1	nanton	1	Trinity River	L	239.2	247.4	6.78	48	7,380	Damaged by 1942 flood. Repaired by local interests. Overtopped with no damage 1957. Dreimage structure repaired by CofE 1959-1960. (Midwey)
1	ruston	2	Trinity River	L	226.2	233.1	10,47	49	9,626	Never overtopped. Local interests installed pumps and strengthened levee 1959-196 (Midway)
No. State Creek			Shat Fork	L	40.7	46.7	3.90	- 92	1,875	Damaged by 1942 and 1945 floods. Repaired by CofE. (Nockwall)
Section Sect	llas			Я		38.9"	12.82	90		
Sect Form And 15	Nullman.	6	Bast Fork and Duck Creek		28.9	30.9	2.50	50	663	
Multinage Creek 1	SUCTION S			B						
Must Park	autoen.	15	Bast Fork and Mistang Creek	L	15.2	20.1	5.16	24	2,745	Damaged by 1942 flood. Repaired and raised by local interests. Overtopped by 195 1958 floods. Repaired by Coff. (Crandall)
Note	sufmen.	13	Rest Fork and Mustang Creek	L	12.3	15.2	6.38		926	Damaged by 19% flood. No repairs made. Damaged by 1957 and 1958 floods. Repairs Coffs.
Number N	Nufmen	10	Sast Pork	B	11.3	15.4	2.44	57	1,499	Overtopped by 1944, 1945 & 1946 floods. Repaired by Coff. Overtopped by 1950, 19: 1958 floods. Repaired by Coff. Local interests raised leves grade 1960. (Crantal
Chambers Orea: 1	Nu Comes	5	East Fork and Buffalo Creek	RAL	8.0	12.0	6.63	51	2,133	
Chambers Greek L	sufaen		Trinity River and East Fork	L	453.0 0.4	458.3 8.0	26.00	36 22	12,130	Overtopped by 1935 flood. Bast Fork by Jan. A May 1949 floods. May damage repair: Cofk. Overtopped by 1957 and 1956 floods. Remared by Cofk. (Rosser, Crandall)
Chapters Creek C S3.3 S5.2 2.00 - 1,500 Continuation of Edits No. 2	llis(4)	1	Chambers Creek	L	55-2		8.00		5,936	
Name	llis	11	Chambers Creek	E.	53-3	55.2	2.00		1,500	
	EVETTO	1	Chumbers Creek	L	43-1	46.6	3.88		1,000	
Control Computer Control	.varro	12	Chumbers Creek	8	42.3	43.1	0.85		(1,094)*	District dissolved. Levee no longer maintained.
Compared to	llis	4		В	1.6	3.0	8.69	~	900	Overtopped by 1944 and 1945 floods. Repaired by Coff.
### Avarro 6 Chambers Creek PML 40.6 kl.0 3.29 . 1,460 Left Build leves partially washed away. #### Avarro 10 Chambers Creek PML 92.8 40.3 13.98 25 7,000 Demoged by 1944, 1945, 1949, 1959, 1957 and 1958 floods. ###################################	Liis	6	Chambers and Onion Creeks	£	42.2	43.0	1.58		(257)•	District not maintained.
### Notes 10 Chambers Creek MAL \$4.6 \$41.0 \$3.25 . 1,460 Left, Built lever partially washed away.	llis	9	Chambers and	£	41.4	42.1 1.6	2.96		(566)*	District not maintained.
Continue Continue	AVATTO	6		HAL			3.25		1,462	left Bank levee partially washed away.
Control Chambers and Control	NETTO	10	Chambers Creek	RAL.	32.8	40.3	13.96	25	7,000	Dumaged by 1944, 1945, 1949, 1952, 1957 and 1958 floods. Repaired by Coff and Local interests. (Corsicana)
Print Creaks R 23,3 28,3 8.69 25 2,606	EVALTO	11	Chambers and Cummins Creeks	i.	29.8	32.6	5-79	25	3,000	Damaged by 1944 flood. Repaired by Coff. Damaged by 1952, 1957, and 1958 floods.
Note			Chambers and Briar Creeks	Ħ				25		Designed by 1944, 1945 and 1950 floods. Repaired by Coff. Dummged by 1952 and 1957 floods. Repaired by local interests. Local interests raised leves grade 1950. (Corsi came.)
Characterist Creeks				T.				~		District not maintained.
Aufman 7 Obtain and Kings 8 33.7 37.1 6.39 23 3,800 Overtopped by 1945 and 1957 floods. Repaired by Cofft (Wahnale) Nufman 12 Outain Creek and Lary Birth L 33.7 35.0 3.50 - (1,070)* District not maintained.	BVarro		Chambers Creeks	L	0.0	3.4	6.55	25		Damaged by 1944, 1945, 1948, 1957, 1958 floods. Repaired by Coff. (Corsteans)
Creeks 5.0 k.6				T.						
Lacy Fork	NUT MAIL	7	Creeks	R	33.7	37.1 4.6	6.39	23	3,800	Overtopped by 1945 and 1957 floods. Repaired by Coff. (Mahank)
rederion 2 Getar Creek R 30.6 33.7 1.84 23 1,282 Overstopped by 1945 and 1957 floods. Repaired by Onfit, (Matanit)	PACTORIS	12	Gedar Greek and Lacy Fork	E-	33-7	35.0	3.50		(1,070)*	District not maintained.
	enderson	2	Gedar Creek	R	30.6	33-7	1.84	53	1,282	Overtopped by 1945 and 1957 floods. Repaired by Coff. (Mahamb)

^{*} Since districts are not maintained, acreages have been omitted from area protected as given in text

- 12. CLIMATE. The climate over the basin is generally mild with the distinctive features of a large range of annual and daily temperatures. In summer, the days are generally hot and the nights moderately warm. Snowfall and sub-freezing temperatures are rare in the lower section of the basin near the Gulf, but are experienced occasionally during the winter season in the more northerly parts of the basin. Generally, the winter temperatures are mild, with occasional cold periods of short duration resulting from the rapid movement of cold high-pressure air masses from the northwestern polar regions and the continental western highlands.
- 13. There are no important topographic features affecting climate in this area. The general elevation of the basin increases gradually from a few feet above sea level at Galveston Bay to approximately 1,250 feet above mean sea level in the extreme headwaters.
- 14. Table 6 gives climatological data relative to temperature, growing season, wind velocity, and humidity at representative United States Weather Bureau stations in and adjacent to the Trinity River Basin. The stations in this table are arranged in geographical order from the headwaters downstream in order to show the gradations of climate. There is a general increase in mean annual temperature, length of growing season, and relative humidity from the headwaters to the Gulf.

TABLE 6
CLIMATOLOGICAL DATA

:Years of: Temperature in degrees Fahrenheit

:com	plete:	: .	Average:	Average	:	:
: re	cord :	Mean :	maximum:	minimum	:Maximum	:Minimum
:	(1):	annual:	daily :	daily	:recorded	:recorded
		65.3	77.3	53·3 53·0	114	-12 - 3
a)	24 53 54 54 54 54 54 66 64 75 66 62 75 66	63.5 64.5 64.8 65.0 66.5 66.0 66.5 66.0 67.0 69.0	76.8 77.2 76.5 76.0 76.6 76.2 76.1 79.0 78.1 78.0 75.8 75.7 79.4 77.8	50.28 51.04.89 53.104.89 55.66.89 56	115 117 113 118 111 112 113 114 115 113 112 108 114 107 108	- 1 - 8 - 3 - 7 - 3 - 8 - 11 - 3 - 7 - 6 - 0 - 2 8 11
		70.1 70.0	76.0 78.5	64.2	101	8 5
erage	:v			Relative	humidity	in percent
ays)	: n	iph : i	mile:6	a.m.:No	on:6 p.m.	:Midnight
243 252 249			77 73 47	80 5	3 53	71 70 - 81
	g seaserage ngth lays)	: record : (1) : 69 18 24 53 a) 45 43 79 64 70 52 54 80 54 66 24 75 56 28 89 73 g season: werage : wer	: record : Mean ::	: record : Mean : maximum: : (1) :annual: daily: 69 65.3 77.3 18 66.0 79.0 24 63.5 76.8 53 64.5 77.2 a) 45 64.8 76.5 43 65.0 76.0 79 66.5 76.6 64 66.0 76.2 70 64.0 76.1 52 66.6 79.0 54 65.5 78.1 80 66.6 78.0 54 66.0 75.8 66 66.2 75.7 24 67.1 79.4 75 68.0 77.8 56 69.0 79.9 28 68.3 77.3 89 70.1 76.0 73 70.0 78.5 g season: wind velocity: Fastest: tays) : mph : mile: 6	: record : Mean :maximum:minimum : (1) :annual: daily : daily 69 65.3 77.3 53.3 18 66.0 79.0 53.0 24 63.5 76.8 50.2 53 64.5 77.2 51.8 a) 45 64.8 76.5 53.1 43 65.0 76.0 54.0 79 66.5 76.6 56.4 64 66.0 76.2 55.8 70 64.0 76.1 51.9 52 66.6 79.0 54.2 54 65.5 78.1 52.9 80 66.6 78.0 55.2 54 66.0 75.8 56.2 66 66.2 75.7 56.7 24 67.1 79.4 54.8 75 68.0 77.8 58.2 56 69.0 79.9 58.1 28 68.3 77.3 59.3 89 70.1 76.0 64.2 73 70.0 78.5 61.4 12 season: Wind velocity: Relative mgth :Average:Fastest: Lays) : mph : mile :6 a.m.:No	: record : Mean :maximum:minimum:Maximum : (1) :annual: daily : daily :recorded 69 65.3 77.3 53.3 114 18 66.0 79.0 53.0 112 24 63.5 76.8 50.2 115 53 64.5 77.2 51.8 117 a) 45 64.8 76.5 53.1 113 43 65.0 76.0 54.0 118 79 66.5 76.6 56.4 111 64 66.0 76.2 55.8 112 70 64.0 76.1 51.9 113 52 66.6 79.0 54.2 114 54 65.5 78.1 52.9 115 80 66.6 78.0 55.2 113 54 66.0 75.8 56.2 112 66 66.2 75.7 56.7 108 24 67.1 79.4 54.8 114 75 68.0 77.8 58.2 107 56 69.0 79.9 58.1 108 28 68.3 77.3 59.3 110 89 70.1 76.0 64.2 101 73 70.0 78.5 61.4 108

⁽¹⁾ All data as of December 31, 1959.

⁽²⁾ Station outside of basin.

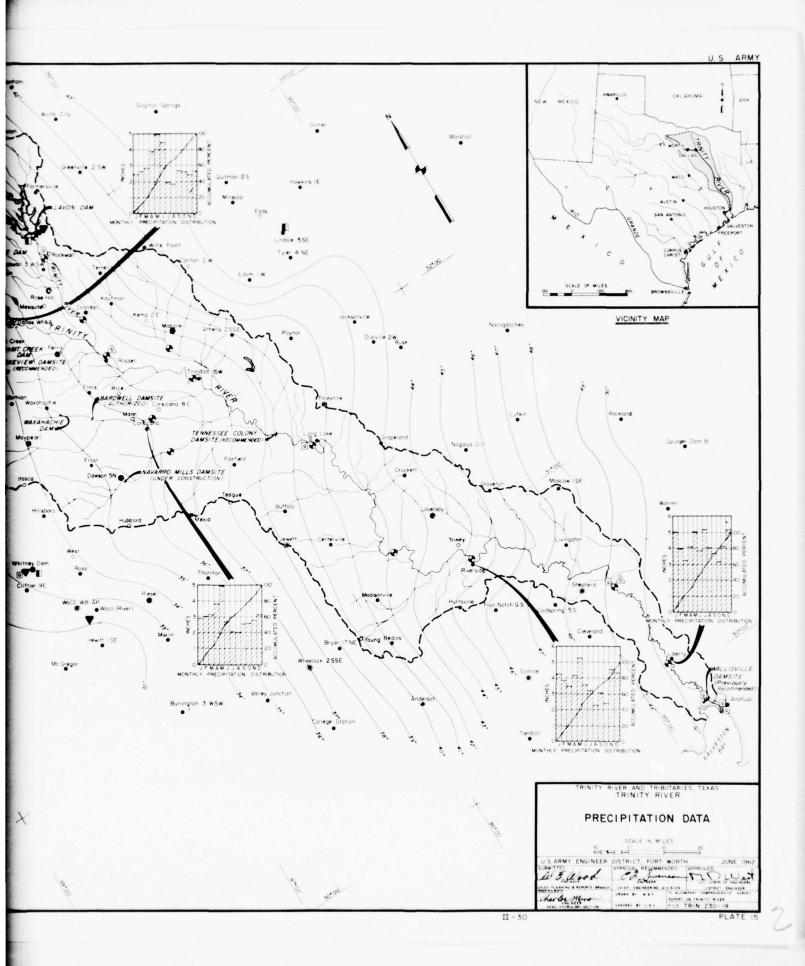
- 15. HUMIDITY. The relative humidity over the basin is generally moderate, decreasing from humid in the lower portion nearest the Gulf to subhumid in the northwestern extremity of the basin. Relative humidity observations have been made by the United States Weather Bureau at Dallas and Fort Worth, in the upper part of the basin; at Palestine, near the eastern border of the central section; and at Galveston and Houston, near the lower part of the basin. Table 6 shows the average humidity for each of these stations.
- 16. WINDS.- The prevailing winds are from the south or southeast during the greater part of the year. Dry southwesterly winds are experienced occasionally. During the winter months, December, January and February, the high-pressure air masses approaching from the northwest, cause the prevailing wind direction to shift to the north. Wind movements are strongest during the months of March and April; and the lightest wind movements generally occur during July, August, and September. The maximum published wind velocity of 91 miles per hour occurred at Galveston in August 1915, during a severe tropical storm. In general, wind movements over the basin are relatively mild. The average annual wind velocities are: 10.9 miles per hour at Galveston, near the lower extremity of the basin; 7.4 miles per hour at Palestine, on the eastern border; and 10.8 and 12.3 miles per hour at Dallas and Fort Worth, respectively, in the upper section of the basin.
- 17. TEMPERATURE. The mean annual temperature varies from 69.0 degrees at Liberty, in the lower part of the basin, to 63.5 degrees at Bridgeport in the northern part of the basin. The mean annual temperature over the basin is about 66 degrees. There is a range in mean monthly temperatures of about 35 degrees between the warmest month, July, and the coldest month, January. Subzero temperatures have been recorded over the northern section of the basin extending as far south as Huntsville. Temperature ranges are rather narrow or oceanic near the coast; but are wide or continental in character in the interior of the basin.
- 18. GROWING SEASON. The growing season between killing frosts normally extends from the latter part of March to the early part of November in the interior of the basin, and from the early part of March to the latter part of November near the coast. The growing season averages 232 days in the northern part of the basin, 277 days in the southern part.
- 19. SNOWFALL. Snowfall is generally light over the basin. It is occasional in the northern part and rare in the southern area near the coast. It comes at infrequent intervals and melts rapidly. Seasonal accumulations are not experienced in this basin, and snowfall therefore does not constitute a flood hazard.

- 20. PRECIPITATION. Precipitation in the Trinity River Basin has been observed officially since 1849, when a station was established by the United States Weather Bureau at Fort Worth, Texas. However, only a few stations were in existence prior to the year 1890. A total of 109 stations have been established in this basin, but at the present time there are only 88 stations in operation. The remainder have been abandoned or their records combined with nearby stations. Of the 28 active automatic recording stations within the basin, only 2 are first-order stations. These are located at Fort Worth and Dallas in the upper part of the basin. Palestine, located in the middle basin, was discontinued as a first-order station in 1953 but the recording precipitation record is continuous to date. Plate 15 shows the locations and type of record of the rainfall stations on and adjacent to the basin.
- 21. ANNUAL RAINFALL. Mean annual precipitation over the basin ranges from a minimum of about 27 inches in the northwestern extremity of the basin to a maximum of 51 inches at the lower end. The average annual precipitation over the basin is about 38 inches. Plate 15 shows isohyetals of mean annual precipitation over the basin, the mean monthly distribution of rainfall at Fort Worth, Dallas, Corsicana, Riverside, and Liberty. Table 7 shows the maximum, minimum, and United States Weather Bureau published normal annual precipitation at stations in and near the basin.

TABLE 7
PRECIPITATION DATA

	: Number : complete :	An	nual prec	ipitation
Station	: years : of record :	Maximum:		:USWB published normal
	:through 1959:	(inches):	(inches)	: (inches)
Anahuac (1)	47	98.08	26.54	53.02
Bridgeport	52	54.55	15.56	29.11
Corsicana	83	61.50	19.36	35.92
Dallas	72	59.53	18.81	34.42
Fort Worth	64	51.03	17.91	33.69
Gainesville	65	52.79	20.37	34.42
Galveston (1)) 88	78.39	21.40	45.19
Graham (1)	65	48.99	14.12	27.02
Huntsville	69	69.79	17.93	45.63
Liberty	55	85.08	29.63	51.15
McKinney	50 78	76.12	20.76	37.48
Palestine		62.48	23.98	40.54
Riverside	56	65.41	27.32	44.22
Waxahachie Weatherford	57 68	54.82 55.88	20.80	35.05 31.54
weatheriord	00)).00	10.00	Jr. / .

⁽¹⁾ Station outside of basin.



22. RAINFALL INTENSITY. Periods of excessive precipitation have been experienced over all parts of the basin. Generally, the highest 24-hour and monthly periods have occurred during major storms. However, there are some instances of heavy precipitation resulting from local thunderstorms. Examples of the latter type of precipitation are the 14.21 inches of rainfall that was observed at Kaufman on August 22-23, 1908, and the 9.18 inches observed at Dallas on August 26-27, 1947. For a further discussion of thunderstorm rainfall see paragraph 31. Maximum 24-hour and maximum monthly precipitation for representative stations in and adjacent to the basin are given in table 8.

TABLE 8

MAXIMUM 24-HOUR AND MAXIMUM MONTHLY PRECIPITATION

Station	: Years of :complete record	:Maximum 24-hour: : rainfall (1):	Maximum monthly rainfall (1)
	: through 1959	: (inches) :	(inches)
Anahuac (2)	47	15.87	20.03
Bridgeport	52	9.07	16.23
Corsicana	83	7.96	17.76
Dallas	. 72	9.18	13.89
Fort Worth	64	9.57	17.64
Gainesville	65	10.07	16.40
Galveston (2)	88	14.35	26.00
Graham (2)	65	5.80	12.54
Huntsville	69	7.78	19.00
Liberty	55	10.22	22.70
McKinney	50	7.55	34.85
Palestine	78	12.06	17.25
Riverside	56	7.50	17.25
Waxahachie	57	10.80	15.03
Weatherford	68	6.75	27.94

⁽¹⁾ Published records. Unofficial observations indicate published records have been exceeded in some areas.

The United States Weather Bureau maintained three recording rain-gaging stations (Fort Worth and Dallas in the Upper Trinity River Basin and Palestine in the middle basin) from which data are obtainable regarding intensities of rainfall for short periods. In addition there are two such stations (Houston and Galveston) near the mouth of the Trinity River, both outside of the basin, which give some indication of rainfall intensities on the lower Trinity River Basin. Table 9 shows the maximum published precipitation at these 5 stations for durations of 24 hours or less.

⁽²⁾ Station outside of basin.

TABLE 9

RAINFALL INTENSITIES AT FIRST-ORDER STATIONS
IN AND NEAR THE TRINITY RIVER BASIN

	0	Total pro	ecipitati	on in in	ches (1)	
Station	: 1-hour	2-hour :	3-hour :	6-hour	: 12-hour	: 24-hour
Fort Worth	3.35	5.59	5.99	6.93	9.04	9.57
Dallas	3.39	4.77	6.24	8.00	9.07	9.18
Palestine	3.24	4.31	4.64	5.25	6.21	12.06
Houston	4.36	6.05	6.62	8.67	10.02	10.83
Galveston	5.31	7.58	8.78	11.79	12.75	14.35

- (1) Published records. Unofficial observations indicate published records have been exceeded.
- 23. EVAPORATION.— An analysis was made of evaporation records as presented by the United States Study Commission for various reservoirs in the Trinity River Basin for the 1941—1957 period. As a result of the analysis it was concluded that such records were reasonable estimates and were therefore adopted for use in this report. These records were based on available data at several stations in and near the basin. Seven of the stations in and adjacent to the basin have comparatively long records Denton in the northen part of the basin; Troup (Lindale) and Nacogdoches, 30 and 40 miles, respectively, east of the basin; College Station and Temple, 20 and 70 miles, respectively, west of the basin; and Beaumont and Angleton, 40 miles northeast and 60 miles south—west, respectively, of the mouth of the Trinity River. The above stations were used to determine evaporation at the reservoirs for the 1924-1940 period not covered by United States Study Commission data. Table 10 gives pertinent data for the seven evaporation stations.

TABLE 10
EVAPORATION DATA

	: ;		:	:Average annua	1: Average
			:	: evaporation	:annual net
Q+ +1	:	Average		: from .	:evaporation
Station	: Period :	annual	Average	: reservoir	: loss from
			l:annual pan):evaporation		: reservoir : surface
	: record :	(1)	: (inches)	: (2)	: (inches)
Denton	1917-1959	32.05	56.60	53.22	21.17
Troup					
(Lindale)	1915-1959	44.59	51.86	48.73	4.14
Nacogdoches	1915-1947	49.32	44.67	41.99	(3)
College					
Station	1916-1955	39.15	55.61	52.28	13.13
Beaumont	1917-1959	54.21	48.31	45.42	(3)
Angleton	1915-1959	47.73	45.12	42.42	(3)
Temple	1915 - 1959	33.62	58.53	55.02	21.40

NOTE: All Texas Agricultural Experiment Stations.

- (1) Corresponding to the period for which evaporation records are available.
- (2) Estimated at 94 percent of pan evaporation.
- (3) Rainfall exceeds evaporation for average conditions.
- 24. Evaporation is greatest in the higher and less humid upper portion of the basin and least in the humid area near the coast. Approximately two-thirds of the annual evaporation normally occurs during the six warm months, April through September, and practically the entire net evaporation loss occurs during the months of June, July, August, and September.
- 25. RIVER STAGE AND DISCHARGE. The observation of Trinity River streamflow began on October 1, 1898, when the United States Geological Survey established a gage at the Turtle Creek pumping plant in Dallas. This gage was abandoned on December 31, 1899. No discharge records were published for this period. In 1903 the United States Weather Bureau established gages at Dallas, Riverside, and Liberty. Subsequently, the Weather Bureau established gages at Bridgeport, Fort Worth, Carrollton, Trinidad, and Oakwood (Long Lake). Prior to 1939 the United States Geological Survey had established a total of 22 streamflow gages on the Trinity River and its tributaries. The greatest expansion in streamgaging activity occurred during the period 1923-1925, when 12 gages were installed. In 1939, the Geological Survey installed 4 new gages

on the Trinity River Basin in cooperation with the Corps of Engineers. Two of these gages were at the location of old gages that had been abandoned, and two were at new locations. Reservoir gages and inflow and outflow gages have been established in connection with the construction of Corps of Engineers reservoirs in the Upper Trinity Basin. For the period 1903-1959 stage and discharge records of varying length were available for 63 streamflow and reservoir gages in the basin. Plates 38 and 39 show the locations and the drainage areas of active and discontinued stream-gaging stations in the basin. Plate 16 shows in bar-graph form the periods covered by records of stream-gaging and reservoir stations.

												_				_	_	_		CA	ALE	ND	AR	TF
GAGE NO.	STREAM	STATION	MILES ABOVE MOUTH	DRAINAGE AREA IN SQ MILES	1965	963	196	1960	959	1983	956	986	953	2961	1950	949	948	1947	1946	1945	043	942	194	1940
	TRINITY RIVER			74											1					7			\exists	7
427	WEST FORK TRINITY RIVER NORTH CREEK	NEAR JACKSBORG	14.0	20							79		-	-	-	-			-	-	+	-		-
428	WEST FORK TRINITY RIVER	NEAR JACKSBORO	660.0	22 683	1	-	+	1		1	200	+	+		1	+	-	+ +	-	-		+ 1	- 1	-
430	BRIDGEPORT RESERVOIR	ABOVE BRIDGEPORT	626.2	1/14					-	1	-		1		1			1	-	-1:	1	1	-	-
435	WEST FORK TRINITY RIVER	AT BRIDGEPORT	620.4	1,147																				
440	BIG SANDY CREEK WEST FORK TRINITY RIVER	NEAR BRIDGEPORT	4.4	332						422	222		422			422	42		77		200			2000
450	EAGLE MOUNTAIN RESERVOIR	ABOVE FORT WORTH	602.0	1,729 1,974			-			422	****	-	7		-	+	-		-	-			_	-
455	WEST FORT TRINITY RIVER AT LAKE WORTH DAM	ABOVE FORT WORTH	583 3 572 I	2,069	1	-		1	LAFE	LANT.		1		Le se	٠,١	,		+	- 1	-	+	1	-	
•	WEATHERFORD RESERVOIR	NEAR WEATHERFORD	38.7	106	1	-	-	+		-	-	-	-		-	-	4-2-	-	-	-	-	-	_	
460	CLEAR FORK TRINITY RIVER	NEAR ALEDO	27.2	246					-	V		22	do	too to	20	100	100	20					- 1	
465	BENBROOK RESERVOIR	NEAR BENBROOK	15.0	433							200													
470	CLEAR FORK TRINITY RIVER CLEAR FORK TRINITY RIVER	NEAR BENBROOK	13.5	435					200			-	2/22	223		7	4	12						
480	WEST FORK TRINITY RIVER	AT FORT WORTH	3.2 558.3	526						1		-	4	-		4	1	1 1				1		22
485	MARINE CREEK	AT FORT WORTH	2.4	2627				1	1	+		+	+		-	4	4	+				4	-	-
488	BIG FOSSIL CREEK	NEAR HALTOM CITY	3.6	53				1		4	*****	-	-		-									+
490	VILLAGE CREEK	NEAR HANDLEY NEAR ARLINGTON	12.0	126					-															
492	LAKE ARLINGTON	NEAR ARLINGTON	8.0	136								-			-	-	-	-		-				
495 500	WEST FORK TRINITY RIVER MOUNTAIN CREEK	AT GRAND PRAIRIE	515.1	3070 273			-	1	VAL.	10	14	142	42		-	44	40	1	22	222	4	1		44
2	MOUNTAIN CREEK RESERVOIR	NEAR GRAND PRAIRIE NEAR GRAND PRAIRIE	46	289		-	+	+	-		-	+	+		+	-				-	-		-	-
502	ELM FORK TRINITY RIVER SUBWATERSHED NO 6-0	NEAR MUENSTER	0.5	203				1	-	+	, ,	-	-		1	1	-			-	-			
503	ELM FORK TRINITY RIVER	NEAR MUENSTER	106.3	46														1 7					- 1	
505	ELM FORK TRINITY RIVER	NEAR SANGER	65.3	379						1		22	4			12	1							
510	ISLE DU BOIS CREEK CLEAR CREEK	NEAR PILOT POINT	6.8	262			-								1	1	4							-
520	ELM FORK TRINITY RIVER	NEAR SANGER NEAR DENTON	12.1	292 1,076	-	-	-	-	1242	4		-4	4		-	4	1	-	-	-		+ 1	-	+
525	LAKE DALLAS	NEAR LAKE DALLAS	39.4	1365	1		-	1			1	-	+		+	+		1 1	- +	-+			\rightarrow	-
527	LITTLE ELM CREEK	NEAR AUBREY	19.1	76				1	CONT.	100	223	-	-	-	1	+	-	-	-	-	-	-		
528	GARZA - LITTLE ELM RESERVOIR	NEAR LEWISVILLE	30.0	1,658						200														
530 535	ELM FORK TRINITY RIVER	NEAR LEWISVILLE	28.2	1,671			-						7				1							
540	DENTON CREEK DENTON CREEK	NEAR JUSTIN NEAR ROANOKE	45.2 27.9	409 621			-	+	-	4	and .	-	-	-	-	+	+	+				******	-	-
545	GRAPEVINE RESERVOIR	NEAR GRAPEVINE	11.7	694	1	-	-		-			-	+	-		-	4	+		-	-	+-+	-	000
550	DENTON CREEK	NEAR GRAPEVINE	72	704					-	+				-	-	1	1	13	-	- 1		1 1	1	-
555	ELM FORK TRINITY RIVER	NEAR CARROLLTON	18 2	2,457					W. Z.	-				22.0					77	-	42	1 7	2	and a
565	TRINITY RIVER																							
570	TURTLE CREEK TRINITY RIVER	AT DALLAS	14	8	-			+	-	-		-				-	100	-					_	-
• 3	TRINITY RIVER	AT DALLAS BELOW DALLAS	500.3 491.9	6,20	1		+		-		-		-		-	4	4	+		-		44	-	2000 00
4	WHITE ROCK LAKE	NEAR DALLAS	94	99					INTER	MITT	ENT	MON	THEY	AKE	LEV	FLS	1	1 1	-	-		1	- 1	-
	EAST FORK TRINITY RIVER							1							1									
575	HONEY CREEK SUBWATERSHED NO II	NEAR MCKINNEY	0.7	2					22	4		4		2	1									
580 585	HONEY CREEK SUBWATERSHED NO 12	NEAR MCKINNEY	0.8	70				1		1		-		2	.							-		
590	HONEY CREEK EAST FORK TRINITY RIVER	NEAR MCKINNEY	56 82.4	39 188	1	-		1 .		1	-	-	1		1	+	+	-		-	-	-	-	+
595	SISTER GROVE CREEK	NEAR PRINCETON	5.2	115				1		1	-			==	-	+	+	1 1		-	-	1	1	+
605	LAVON RESERVOIR	NEAR LAVON	55.9	777								1	1		-	-		1					1	+
610	EAST FORK TRINITY RIVER	NEAR LAVON	54.9	779					2	2000	900	200	33											
615	EAST FORK TRINITY RIVER	NEAR ROCKWALL	44.2	840									-		-		-	_	-		-	_	_	-
620	DUCK CREEK EAST FORK TRINITY RIVER	NEAR GARLAND	8.3	31				1		1						+	+			-	-			-
625	TRINITY RIVER	NEAR CRANDALL NEAR ROSSER	451.4	1257 8162	1			1	-	1	-	-	+	-	-	+	+	t			-	4	-	-
5	TRINITY RIVER	AT TRINIDAD	3916	8,566					-	1			4	-		-	1	1-1		-	-	-	-	-
630	CEDAR CREEK	NEAR MABANK	306	734				1	W. 1	3/1/2	22.2		1	200		100	1	1 1			***	1		nu i
	RICHLAND CREEK							1																
640	WAXAHACHIE RESERVOIR CHAMBERS CREEK	NEAR WAXAHACHIE NEAR EMHOUSE	02 42.2	818	1			1				+	-		1					-		1		-
645	CHAMBERS CREEK	NEAR CORSICANA	23.4	971	+	-	-	1	-		-		+	-	-	+	-	+	-		-		-	1000
632	PIN OAK CREEK	NEAR HUBBARD	24.2	18			1	1	-	1	7		*****		-	+	4	*****				*****	-	-
635	RICHLAND CREEK	NEAR RICHLAND	36.0	737					600			1	1		22	1	1	1 1	-	2	1	1	-	-
650	TRINITY RIVER	NEAR OAKWOOD (LONG LAKE)	313.4	12,912						1		1	7			1	1			-	1			100
655 660	TRINITY RIVER TRINITY RIVER	NEAR MIDWAY	230.2	14,484							-						F						#	3
665	TRINITY RIVER	AT RIVERSIDE AT ROMAYOR	182.5 94.3	15,619	1			1								ļ	4			***			_	
+ 670	TRINITY RIVER	AT LIBERTY	40.3	17,192	1		+	+ +	Secretary.	-		***	· delen	*****		****	-	*****			-4			-

NOTES
Gage numbers refer to USGS permanent numbering system. This basin is located in the Western Gulf of Mexico Basin Prefix 080 to number shown to obtain complete gage number (Example Gage 590, East Fark above McKinney, is actually 080590)

No permanent USGS number assigned to these gages.
Refer to plates 38 and 39 for location of stream gaging stations.

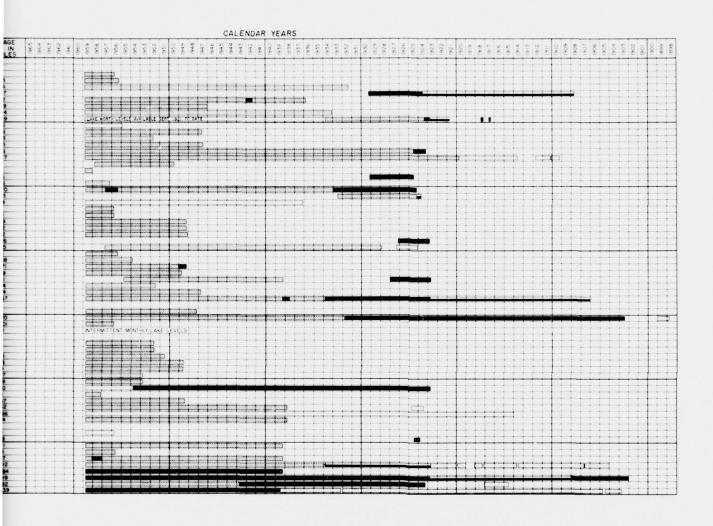
Obscharge not computed below page height of 10 feet.

stations

• Discharge not computed below gage height of 10 feet because tides affect the stage-discharge relation

LEG

USGS REC RESERVOIR USGS NON ESTIMATED GAGE - HEIGH



LEGEND

WWW. USGS RECORDING GAGE RECORD RESERVOIR CONTENTS USGS NON-RECORDING RECORD ESTIMATED BY USGS. GAGE - HEIGHT RECORD

TRINITY RIVER

PERIOD OF RECORD FOR RESERVOIR AND STREAM GAGING STATIONS

U.S. ARMY ENGINEER DISTRICT, FORT WORTH JUNE 1962
SURVEY FOR AND APPROVAL PROMETED A

26. ANNUAL RUNOFF. - Observed average annual runoff at the principal gages in the Trinity River Basin are given in table 11. Also given are the minimum and maximum annual runoff for the purpose of illustrating the extremes to which the annual runoff in this basin is subject.

TABLE 11

ANNUAL RUNOFF DATA (OBSERVED) (1)

CALENDAR YEAR

	:Drainage:	Period	Runo	off in in	aches
Stream and station	: area :				
Stream and station				_	e:Maximum
	:(sq.mi.):	record :	annual	annual	:annual
West Fork at Bridgeport	1,1.47	1908-1930	0.59	2.48	6.50
Big Sandy Creek near					
Bridgeport	332	1937-1959	0.17	3.61	15.01
Clear Fork near Aledo	246	1947-1959	0.09	2.21	5.18
Clear Fork near Benbrook	435	1947-1959	0.03	2.15	7.21
Clear Fork at Fort Worth	526	1924-1959	0.07	2.70	8.23
West Fork at Fort Worth	2,627	1921-1959	0.06	2.18	7.93
West Fork at Grand Prairie	3,070	1925-1959	0.31	2.51	8.30
Elm Fork at Lewisville	1,671	1949-1959	0.81	4.01	13.35
Denton Creek near Roanoke	621	1924-1955	0.32	3.65	11.49
Trinity River at Dallas	6,120	1903-1959	0.28	3.32	10.01
East Fork near Rockwall	840	1923-1954	0.02	7.71	21.02
East Fork near Crandall	1,257	1949-1959	0.41	5.75	16.57
Trinity River near Rosser	8,162	1938-1959	0.48	4.61	10.87
Cedar Creek near Mabank	734	1939-1959	1.54	8.69	18.01
Richland Creek near Richlan		1939-1959	0.89	7.26	18.11
Chambers Creek near Corsica		1939-1959	0.43	6.54	15.76
Trinity River near Oakwood	12,912	1923-1959	0.82	5.10	12.78
Trinity River near Midway	14,484	1939-1959	0.88	5.63	13.11
Trinity River at Riverside	15,619	1903-1959	0.94	5.71	13.27
Trinity River at Romayor	17,192	1924-1959	1.00	5.83	13.39
are are aroundly or	-1,7-7-	-////		,	-3.37

⁽¹⁾ Observed runoff reflects historical depletions due to storages, evaporation, diversions, etc., in existing local interest and Corps of Engineers projects.

^{27.} The data in table 11 indicate that the annual runoff tends to increase from the headwaters toward the mouth. This is to be expected because of the greater rainfall on the lower part of the basin.

- 28. Runoff values in studies of basin development were based on: (1) existing conditions of runoff, determined from observed records at stream-gaging stations with applicable reduction factors applied to account for existing developments on the basin, and (2) the 2020 conditions of runoff, determined as follows: An analysis was made of the runoff for the 1941-1957 period as presented by the United States Study Commission Texas. As a result of this analysis it was concluded that such runoff constituted a reasonable estimate and was therefore used with the following exception. Detailed operational records from the Dallas Power and Light Company at the existing Mountain Creek Dam were used by the Corps of Engineers to determine the runoff on Mountain Creek. For the period 1924-1940 the runoff was determined from observed records at stream-gaging stations with applicable reduction factors applied to reduce these flows to 2020 conditions of basin development.
- 29. DROUGHTS .- There have been two major droughts experienced on the Trinity River Basin - 1908-1913 and 1950-1957. Due to paucity of records during the 1908-1913 period, the latter drought period, due to its areal coverage, duration and the availability of data, has been adopted as the critical period with respect to water supply for this report. The drought of 1950-1957 was terminated by the floods of April-June 1957. Excessive runoff also occurred during the earlier part of 1950. The calendar years 1951 through 1956 were, however, entirely within the drought period. The mean annual runoff on the Trinity River at Dallas (in the upper basin) and Romayor (in the lower basin), based upon the entire period of observed record at the two gaging-stations, is 3.32 inches and 5.83 inches, respectively. The mean annual runoff for calendar years 1951 through 1956 was only 0.54 inch at Dallas and 2.14 inches at Romayor. Normal precipitation at the Dallas and Liberty gages, as published by the U. S. Weather Bureau, is 34.42 inches and 51.15 inches, respectively. During the period 1951-1956 the mean annual precipitation was 25.39 inches at Dallas and 41.47 inches at Liberty. These represent average annual rainfall deficiencies of 9.03 inches and 9.68 inches at Dallas and Liberty, respectively, during the period 1951 through 1956.
- 30. STORM CHARACTERISTICS. The storms that cause precipitation on the Trinity River Basin are of three general types: (1) thunderstorms, culminating in devastating cloudbursts; (2) frontal storms; and (3) cyclonic storms originating in the tropics or the western Gulf of Mexico. Approximately three-fourths of the precipitation on the basin results from disturbances of the first two types and the remaining one-fourth from disturbances originating in the tropics or the Gulf of Mexico. The tropical and Gulf storms occur principally during the period from June to November, inclusive.

- 31. THUNDERSTORMS .- Thunderstorms, as here described, are produced and maintained by local convectional currents of the vertical type. They are sometimes accompanied by excessive precipitation for periods up to about 6 or 8 hours, but rarely produce excessive precipitation over extensive areas. Thunderstorms cause freshets and even major floods on the smaller tributaries, but do not produce major floods in the larger streams. Thunderstorms, however, often cause damage to the levee districts on the larger tributaries and on the main river by breaching the lateral or hillside levees and covering the protected lands within the levee districts with the floodwaters and debris collected from the local watershed. The floods produced by these storms are especially damaging to crops because they occur most frequently in the growing season. This type of storm is exemplified by the rainfall of 14.21 inches observed at Kaufman on August 22-23, 1908. The area covered by the intense precipitation was probably small, since practically no precipitation was observed at surrounding stations. Although no information is available on the distribution of this rainfall, it is probable that the greater part of the 14.21 inches recorded for 24 hours fell in a much shorter period. A more recent example of thunderstorm type rainfall occurred at Dallas on August 26-27, 1947 where 9.18 inches fell in a period of 24 hours with 9.07 inches occurring in a period of only eleven hours.
- 32. FRONTAL STORMS. Frontal storms that cause precipitation on this basin result from the forced ascension of warm moisture-laden air masses originating over the warm oceanic areas to the south. The lifting of the warmer air mass is accomplished either by direct convergence of a tropical air mass and a polar air mass, or by the convergence and partial emcompassing of a tropical air mass by several denser air masses. The greatest storms of record that have been experienced on the Trinity River Basin are of the frontal type. Some examples of the frontal type storm are those of May 22-26, 1908; December 1-5, 1913; May 24-31, 1929; and September 25-28, 1936.
- 33. CYCLONIC STORMS. It remains to consider the characteristics of the cyclonic storm which originates in the tropics and the western Gulf of Mexico. When these storms move inland they tend to curve to the northeast and to pass up the Mississippi Valley. In following this course, the storm center would most likely cross the lower portion of the basin somewhere below Dallas, where its width is relatively narrow and the land slopes are not steep. The heaviest precipitation in these storms is generally experienced in the right front quadrant. Hence, the greatest precipitation would tend to be concentrated on the lower portion of the basin. The severe tropical storm of August 17-20, 1915, is an example of the cyclonic storm.

- 34. MAJOR BASIN STORMS. Some of the major flood-producing storms that have occurred over the Trinity River Basin are as follows: June 28-July 1, 1899; May 22-26, 1908; December 1-5, 1913; April 20-26, 1915; April 24-27, 1922; May 24-31, 1929; September 25-28, 1936; November 19-26, 1940; April 5-30, 1942; April 29-May 4, 1944; March 28-April 2, 1945; May 16-17, 1949; and April-June 1957. Isohyetal maps and typical mass curves of precipitation for selected major basin storms are shown on plates 17 through 20, and a description of these storms is given in the following paragraphs.
- 35. STORM OF JUNE 28-JULY 1, 1899. The center of this storm was located at Hearne (about 60 miles west of the Trinity River Basin) where rainfall of 34.5 inches was recorded for the 108-hour storm period. The heaviest concentration of rainfall in the Trinity River Basin occurred on the Richland and Chambers Creek watersheds and in the lower portion of the Trinity River Basin below the mouth of Richland Creek where the following rainfall amounts were recorded: Mann (near Corsicana), 10.0 inches, Palestine, 7.5 inches; and Huntsville, 7.6 inches. An isohyetal map and typical mass curves of precipitation for the storm of June 28-July 1, 1899 are shown on plate 17.
- 36. STORM OF MAY 22-26, 1908.— The center of this storm was at Chattanooga in southern Oklahoma where rainfall of 9.4 inches was recorded for the storm period. This storm covered the entire headwaters of the Trinity River down to the mouth of the East Fork with the heaviest concentration over the Elm Fork watershed. Between 8 and 9 inches of rain fell over the upper portion of the Elm Fork watershed and from 4 to 8 inches over the greater part of the Trinity River Basin above Dallas. Practically no rainfall was recorded on the Trinity River Basin below the mouth of the East Fork. Some of the rainfall amounts on the Upper Trinity River Basin were as follows: Gainesville, 8.3 inches; Fort Worth, 7.3 inches; Weatherford, 6.4 inches; and Dallas, 4.0 inches. An isohyetal map and typical mass curves of precipitation for the storm of May 22-26, 1908 are shown on plate 17.
- 37. STORM OF DECEMBER 1-5, 1913. The center of this storm was at San Marcos in south central Texas (about 100 miles southwest of the Trinity River Basin) where rainfall of 15.5 inches was recorded for the 96-hour storm period. This storm generally covered that portion of the Trinity River Basin between the mouth of the East Fork and the Riverside gage with the heaviest concentration of rainfall on the watersheds of Richland, Chambers, and Cedar Creeks. Some of the higher rainfall amounts within the storm area on the Trinity River Basin were as follows: Kaufman, 11.7 inches; Waxahachie, 8.2 inches; Corsicana, 9.0 inches; Long Lake, 8.5 inches; and Riverside, 5.3 inches. An isohyetal map and typical mass curves of precipitation for the storm of December 1-5, 1913 are shown on plate 17.

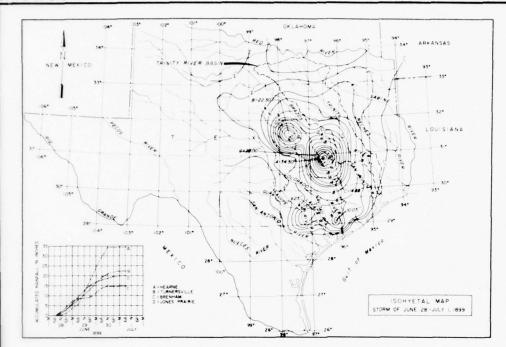
- 38. STORM OF APRIL 20-26, 1915. The center of this storm was at Austin, Texas (about 90 miles west of the Trinity River Basin) where rainfall of 17.1 inches was recorded for the storm period. This storm generally covered the East Fork watershed and that portion of the Trinity River Basin between the mouth of the East Fork and the Oakwood (Long Lake) gage. Rainfall amounts recorded within this area were as follows: McKinney, 6.6 inches; Trinidad, 8.0 inches; and Long Lake, 5.3 inches. An isohyetal map and typical mass curves for the storm of April 20-26, 1915 are shown on plate 17.
- 39. STORM OF APRIL 24-27, 1922. The center of this storm was at Weatherford, in the Clear Fork watershed, where rainfall of 11.4 inches was recorded for a period of about 30 hours. The storm generally covered the Upper Trinity River Basin with the heaviest concentration on the Clear Fork. Rainfall amounts recorded within the storm area on the Upper Trinity River Basin were as follows: Weatherford, 11.4 inches; Fort Worth, 10.6 inches; Dallas, 5.8 inches; and Waxahachie, 6.3 inches.
- 40. STORM OF MAY 24-31, 1929. The center of this storm was at Driftwood (near Austin and about 100 miles west of the Trinity River Basin) where rainfall of 15.0 inches was recorded for the storm period. The 5-inch isohyet for this storm enveloped practically the entire area of the Trinity River Basin between the mouth of East Fork and Liberty gage. Rainfall amounts recorded within this area were as follows: Huntsville, 10.8 inches; Mexia, 8.4 inches; Crockett, 6.5 inches; Riverside, 9.9 inches; and Liberty, 4.5 inches. An isohyetal map and typical mass curve of precipitation for the storm of May 24-31, 1929 are shown on plate 18.
- 41. STORM OF SEPTEMBER 25-28, 1936.— This storm was centered at Hillsboro, just outside the Trinity River Basin, where rainfall of 15.5 inches was recorded within the storm period. Rainfall of an almost equal amount (14.7 inches) was recorded at Ennis in the Chambers Creek watershed. Although the storm had a duration of 90 hours, the greater part of the rain fell in a period of from 12 to 18 hours. The heaviest concentration of rainfall within the Trinity River Basin occurred on the watersheds of Mountain, Richland, Chambers, and Cedar Creeks. Rainfall amounts recorded within this area of heaviest concentration were as follows: Kaufman, 14.2 inches; Ennis, 14.7 inches; Mountain Creek, 11.3 inches; Waxahachie, 10.3 inches; and Corsicana, 7.0 inches. An isohyetal map and typical mass curves of precipitation for the storm of September 25-28, 1936 are shown on plate 18.
- 42. STORM OF NOVEMBER 19-26, 1940. The center of this storm was at Hempstead (about 80 miles west of the Trinity River Basin) where rainfall of 21.0 inches was recorded for the storm period. Heavy rainfall was experienced on the central and southern portions of the Trinity River Basin during this storm. Some of the higher

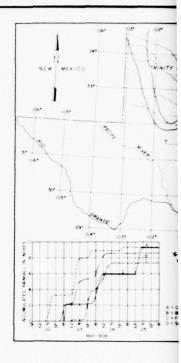
rainfall amounts recorded in the basin during this storm were as follows: Long Lake, 19.6 inches; Centerville, 20.0 inches; and Shepherd, 16.7 inches. An isohyetal map and typical mass curves of precipitation for the storm of November 19-26, 1940 are shown on plate 18.

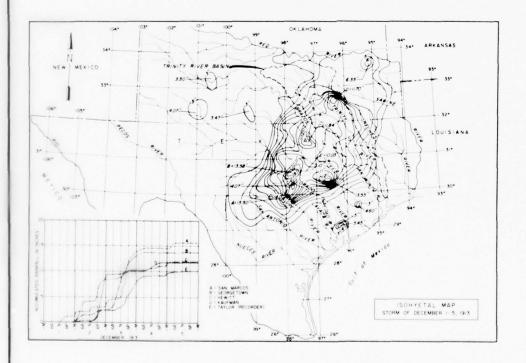
- 43. STORM OF APRIL 5-30, 1942. This storm covered the entire Trinity River Basin. Storm centers were scattered throughout the basin; however, the heaviest concentration of rainfall was experienced in the upper basin. The storm of April 5-30, 1942 consisted of four distinct periods of rainfall. These periods were as follows: April 5-9, April 12-14, April 18-20, and April 23-30. Precipitation during the first period fell at moderate rates on relatively dry ground and did not produce excessive runoff on the tributaries. The second period consisted of light rains of little significance. The third and fourth periods consisted of several short periods of intense precipitation and generally produced the high discharge experienced in the basin. Some of the rainfall amounts recorded in the basin during the total storm period of April 5-30 were as follows: Roanoke, 18.8 inches; Gainesville, 16.4 inches; Fort Worth, 17.0 inches; Dallas, 12.4 inches; McKinney, 17.1 inches; Rosser, 13.7 inches; Trinidad, 8.3 inches; Long Lake, 8.0 inches; and Liberty, 8.5 inches. An isohyetal map and typical mass curves of precipitation for the storm of April 5-30, 1942 are shown on plate 19.
- 44. STORM OF APRIL 29-MAY 4, 1944. The center of this storm was at Pollok (about 30 miles east of Crockett) where rainfall of 16.0 inches was recorded for the storm period. This storm generally covered the Trinity River Basin below Dallas. Some of the rainfall amounts recorded in the Trinity River Basin were as follows: Denton, 3.6 inches; Dallas, 5.9 inches; Trinidad, 7.8 inches; Jewett, 11.9 inches; Riverside, 4.9 inches; and Liberty, 6.4 inches. An isohyetal map and typical mass curves of precipitation for the storm of April 29-May 4, 1944 are shown on plate 18.
- 45. STORM OF MARCH 28-April 2, 1945.— The center of this storm was at Winnsboro (about 60 miles east of the Trinity River Basin) where rainfall of 15.5 inches was recorded for the storm period. This storm generally covered the Trinity River Basin between Dallas and Oakwood (Long Lake) and the West Fork watershed below Fort Worth. Some of the rainfall amounts recorded in the Trinity River Basin were as follows: Fort Worth, 3.5 inches; Mansfield, 9.8 inches; Rosser, 8.7 inches; Trinidad, 8.2 inches; Kemp, 10.0 inches; and Long Lake, 5.4 inches.
- 46. STORM OF MAY 16-17, 1949. The center of this storm was at Kennedale on the Village Creek watershed (a tributary of the West Fork) where rainfall of 12.8 inches was recorded in a period of 9 hours.

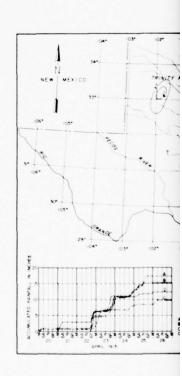
The heaviest rainfall for this storm occurred on the Clear Fork watershed and on that portion of the West Fork watershed lying between Fort Worth and Dallas. Heavy rainfall with an average depth of 8.75 inches on the area of the Clear Fork between the Aledo and Fort Worth gages produced the maximum flood of record on the Clear Fork at the Fort Worth gage. Some of the rainfall amounts recorded in the storm area were as follows: Weatherford, 10.0 inches; Aledo, 11.0 inches; Fort Worth, 8.0 inches; Hurst, 10.0 inches; and Dallas, 5.4 inches.

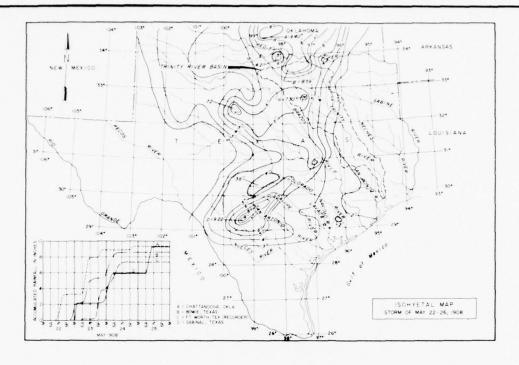
47. STORMS OF APRIL JUNE 1957. The storms which began over Texas on April 19 produced rainfalls during the month varying from about 8 inches in the lower Trinity River Basin to about 10 inches in the central portion of the basin to a maximum of about 20 inches in the upper basin near the Garza-Little Elm Reservoir. During the month of May, the storms continued over the basin producing rainfalls varying from about 2 inches near the mouth to about 4 inches in the central basin near Oakwood to about 16 inches on the watersheds of the East, Elm, and West Forks. Rainfall totals over the basin for the month of June were more moderate, ranging from about 2 inches in the upper basin to about 10 inches at the extreme lower end of the basin. The heavy general rains ended about June 5 and for the remainder of the month such rainfall as occurred was in the form of scattered showers. The most significant periods of flood runoff resulting from the series of storms which occurred during the period of April-June 1957 were during the latter part of April, about the middle and end of May, and the early part of June. Flows in the river continued high during June due to releases from the upper Trinity River reservoirs where the flood-control storage was being evacuated. Although none of the peak discharges exceeds the record peak discharges of the respective gages, the volume of runoff exceeded that produced during any similar period for which records are available. The floods of April -June 1957 on the Trinity River Basin above Dallas produced about 3,888,000 acre-feet of runoff (adjusted for storage in upstream reservoirs), whereas the floods of April June 1908 produced only about 2,400,000 acre-feet of runoff or about one and one-half times as much flood runoff occurred on the Trinity River Basin above Dallas as during the floods of April-June 1908 which produced the maximum known peak discharge at Dallas. The West Fork watershed above Fort Worth produced about 1,278,000 acre-feet of runoff (adjusted for storage), during the April-June 1957 floods or about five times the flood volume of the April-June 1949 flood (255,000 acre-feet) which produced the maximum known peak discharge on the Clear Fork at Fort Worth. Isohyetal maps and typical mass curves of precipitation for April, May, and June 1957, and for the total period of April through June 1957 are shown on plate 20.

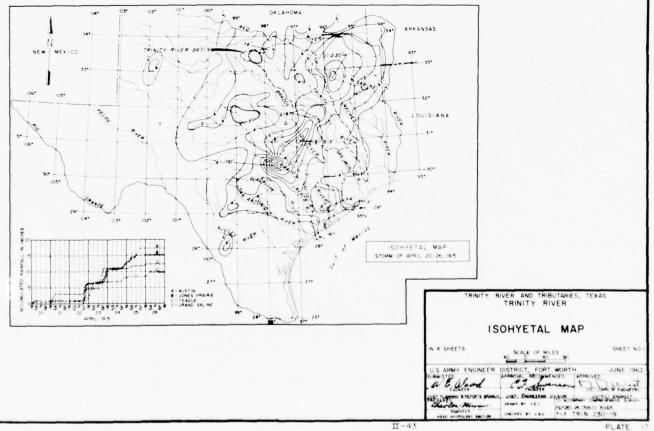




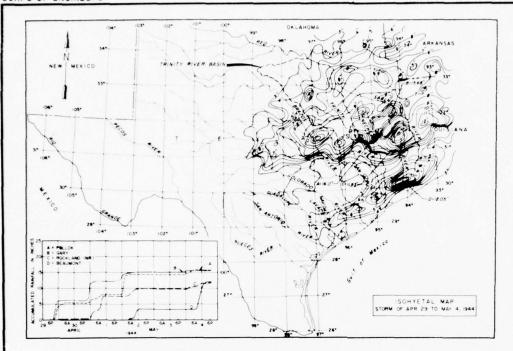


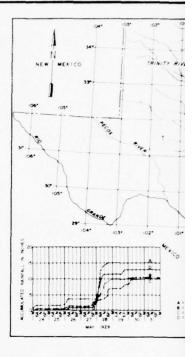


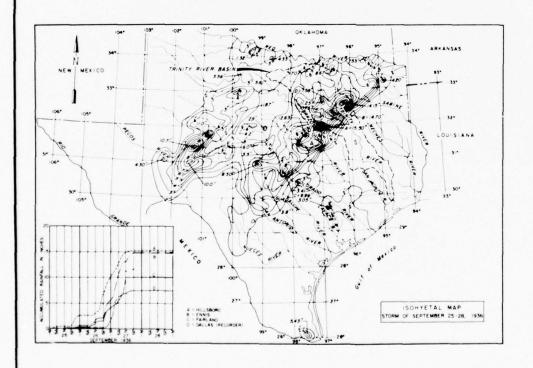


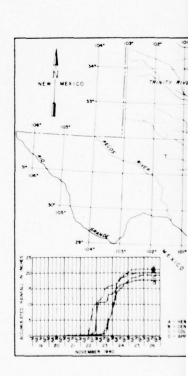


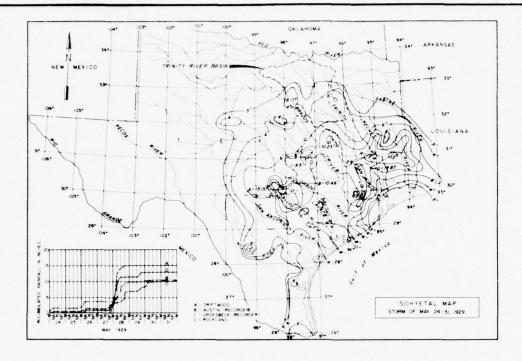
PLATE

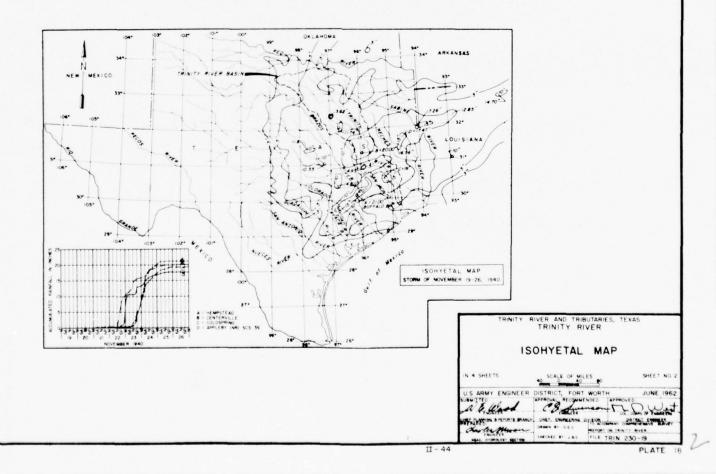


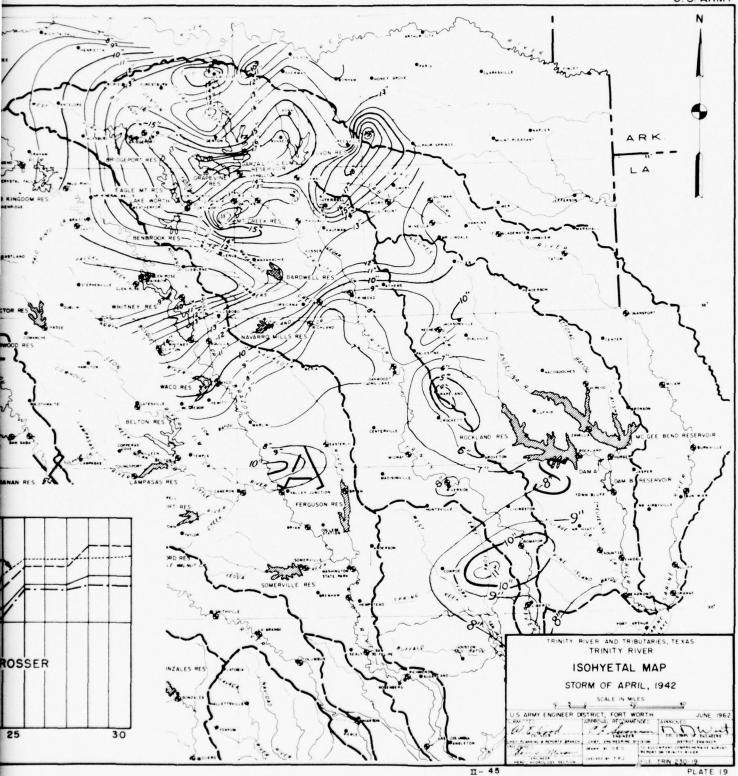


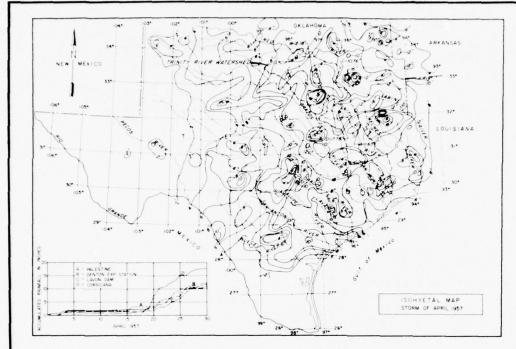


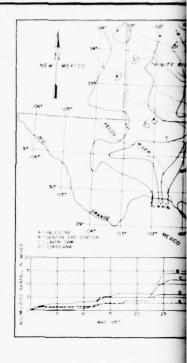


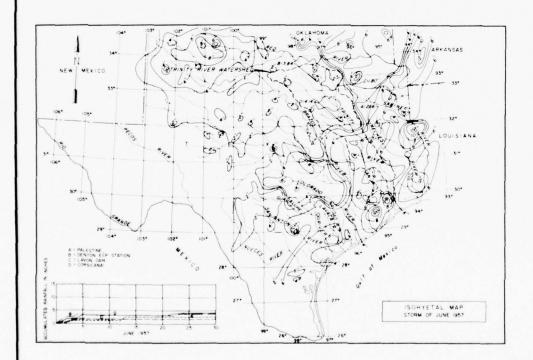


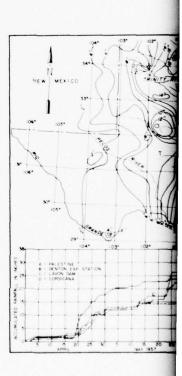


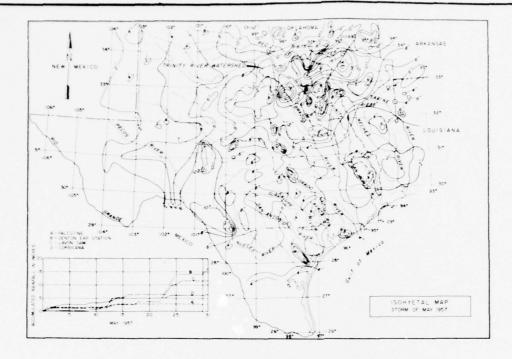












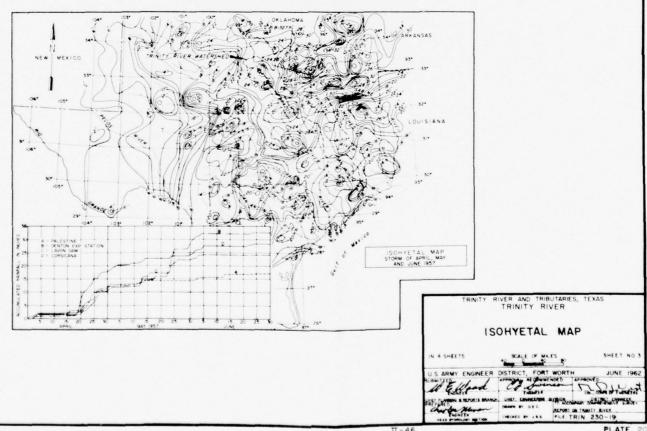


PLATE 20

48. FLOODS.- Floods occur frequently and at almost any time of the year on the Trinity River Basin. Table 12 gives peak discharges and volumes for some of the larger floods at some of the principal gages in the basin:

TABLE 12
FLOOD DATA

Date of flood	: : di	Peak scharge	: I	Oate of	:	Flood vo passing	
	:	(cfs)	: 1	peak	_ :	(acre-feet):	(inches)
WEST FORK TRINITY	RIVER	AT FORT	WOF	RTH -	D.	A. = 2,627 SQ	. MI.
April 23-May 7, 1922 April 18-May 16, 1942 March 29-April 21, 1945 May 15-25, 1949 April 18-July 5, 1957		85,000 23,700 31,200 64,300(1 26,800(2	Ag Ma	or 25 or 24 ar 30 ay 17 ay 25		265,600 417,500 172,500 125,000 792,300	1.90 2.98 1.23 0.89 5.66

(1) Affected by major levee breaks.

(2) Discharge estimated at 58,800 second-feet without Benbrook Reservoir in operation.

WEST FORK TRINITY RIVER AT GRAND PRAIRIE - D. A. = 3,070 SQ. MI.

April 18-May 18, 1942	27,200	Apr 25	521,500	3.18
March 29-April 21, 1945	29,500	Mar 31	251,800	1.54
May 15-25, 1949	62,000(1)	May 17	213,600	1.31
April 19-July 6, 1957	59,200(2)	May 26	1,040,200	6.35

(1) Affected by major levee breaks.

(2) Discharge estimated at 68,800 second-feet without Benbrook Reservoir in operation.

FLOOD DATA

	:	Peak		Date	:	Flood volume
Date of flood	:	discharge				passing gage
	:	(cfs)	:	peak	:	(acre-feet): (inches)

TRINITY RIVER AT DALLAS - D. A. = 6,120 SQ. MI.

184,000	May 25	1,354,100	4.15
75,100	Apr 27	531,600	1.63
77,000	June 12	980,600	3.00
111,000	Apr 26	1,521,400	4.66
52,900	Mar 31	685,100	2.10
38,900	June 2	564,900	1.73
82,500(1)	May 18	392,100	1.20
75,300(2)	May 26	2,679,500	8.20
23,200(2)	Apr 27	896,200	2.75
	75,100 77,000 111,000 52,900 38,900 82,500(1) 75,300(2)	75,100 Apr 27 77,000 June 12 111,000 Apr 26 52,900 Mar 31	75,100 Apr 27 531,600 77,000 June 12 980,600 111,000 Apr 26 1,521,400 52,900 Mar 31 685,100 38,900 June 2 564,900 82,500(1) May 18 392,100 75,300(2) May 26 2,679,500

(1) Affected by major levee breaks.

(2) Discharge estimated at 222,000 second-feet and 98,500 second-feet in 1957 and 1958, respectively, without Corps of Engineers reservoirs in operation.

TRINITY RIVER AT ROSSER - D. A. = 8,162 SQ. MI.

June 2-July 10, 1941	55,300	Jun 16	1,694,800	3.89
April 20-May 17, 1942	(1)	(1)	2,128,700	4.89
April 29-May 18, 1944	39,000	May 6	500,400	1.15
March 28-May 5, 1945	66,600	Apr 2	946,700	2.17
May 28-June 19, 1946	54,800	Jun 4	996,500	2.29
May 16-27, 1949	51,900	May 21.	473,000	1.09
April 19-September 5, 1957	56,000(2)) May 29	4,045,900	9.29
April 13-June 12, 1958	34,000(2)) May 3	1,426,600	3.28

⁽¹⁾ Maximum discharge not determined, occurred April 23 or 24 following numerous breaks in levee system, average daily discharge on April 23 was 133,000 second-feet.

(2) Discharge estimated at 142,000 and 100,000 second-feet in 1957 and 1958, respectively, without existing Corps of Engineers reservoirs.

FLOOD DATA

	:	Peak	*	Date	:	Flood vo	lume
Date of flood	:	discharge	:	of		passing	
	:	(cfs)	:	peak	:	(acre-feet) :	(inches)

TRINITY RIVER AT OAKWOOD - D. A. = 12,912 SQ. MI.

1890	180,000	(1)	(1)	(1)
May 29-June 11, 1908	164,000	Jun 4	2,490,900	3.62
April 25-May 12, 1922	67,100(2)	May 2	1,515,300	2.20
June 2-July 16, 1941	69,300(2)	Jun 22	2,333,600	3.39
April 23-May 22, 1942	153,000	Apr 29	3,330,800	4.84
April 30-May 20, 1944	111,000	May 5	1,828,200	2.65
March 31-May 13, 1945	140,000	Apr 3	2,955,100	4.29
May 28-June 20, 1946	54,000	Jun 10	1,366,800	1.98
May 18-June 12, 1949	28,600(2)	May 30	741,300	1.08
April 19-September 9, 1957	91,800(3)	-	6,553,600	9.52
April 11-June 15, 1958	95,400(3)	May 7	2,395,600	3.48

Data not available.

(2) Average daily discharge.(3) Discharge estimated at 137,100 and 110,500 second-feet in 1957 and 1958, respectively, without existing Corps of Engineers reservoirs.

TRINITY RIVER AT RIVERSIDE - D. A. = 15,619 SQ. MI.

May 24-July 7, 1908	100,000	Jun 11	3,662,900	4.40
April 25-May 20, 1922	73,300(1)	May 4	2,773,600	3.33
June 3-July 21, 1941	47,500(1)	Jul 2	2,639,600	3.17
April 21-May 29, 1942	121,000	May 5	4,192,400	5.03
April 30-June 1, 1944	83,000	May 11	2,723,400	3.27
March 30-May 10, 1945	116,000	Apr 9	3,769,600	4.53
May 31-June 30, 1946	40,200	Jun 19	1,618,200	1.94
May 22-June 15, 1949	23,400(1)	Jun 5	727,100	0.87
April 21-September 11, 1957	97,700(2)	May 4	7,694,400	9.24
April 13-June 17, 1958	66,800(2)	May 14	2,782,500	3.34

(1) Average daily discharge.

⁽²⁾ Discharge estimated at 130,500 and 109,000 second-feet in 1957 and 1958, respectively, without existing Corps of Engineers reservoirs.

FLOOD DATA

	:	Peak	:	Date	:	Flood	vol	ıme
Date of flood	:	discharge	:	of	:	passir	ng ga	age
	:	(cfs)	:	peak	: -	(acre-feet) ;	(inches)

TRINITY RIVER AT ROMAYOR - D. A. = 17,192 SQ. MI.

June 5-July 31, 1941	44,100(1)	Jul 5	3,047,500	3.32
April 21-June 1, 1942	111,000	May 9	4,751,700	5.18
April 30-June 6, 1944	69,000	May 15	3,216,900	3.51
March 31-May 15, 1945	106,000	Apr 13	4,340,200	4.73
May 31-July 6, 1946	40,600(1)	Jun 23	1,844,500	2.01
May 23-June 21, 1949	23,400(1)	Jun 7	820,700	0.89
April 23-September 15,	1957 93,200(2)	May 10	8,234,100	8.98
April 13-June 18, 1958	58,200(2)	May 19	2,797,600	3.05

(1) Average daily discharge.

(2) Discharge estimated at 125,900 and 102,000 second-feet in 1957 and 1958, respectively, without existing Corps of Engineers reservoirs.

MOUNTAIN CREEK NEAR GRAND PRAIRIE - D. A. = 289 SQ. MI.

Dec. 15-Jan. 4, 1928	35,900	Dec 17	31,700	2.06
May 8-18, 1930	18,800	May 15	27,400	1.78
April 18-May 19, 1942	29,300(1)	Apr 20	89,400	5.80
March 29-31, 1945	23,100(1)	Mar 30	52,700	3.42
May 29-31, 1946	18,500(1)	May 30	42,500	2.76
February 23-25, 1949	19,200(1)	Feb 24	51,500	3.34
April 19-June 5, 1957	25,400(1)	Apr 26	133,300	8.65

⁽¹⁾ Peak discharges estimated from changes in reservoir contents and releases from Mountain Creek Reservoir.

6.

FLOOD DATA

Date of flood	Peak discharge	: Dat		•	volume ng gage
	(cfs)	: pea	ak	: (acre-feet) : (inches)
ELM FORK AT (CARROLLTON -	D. A.	= 2,1	+57 SQ. MI.	
December 9-20, 1913	76,000	Dec	14	289,900	2.21
May 12-26, 1935	82,100(1)	May	19	466,900	3.56
June 6-July 1, 1941	76,400(1)	Jun	12	561,900	4.29
April 18-May 17, 1942	90,700(1)	Apr	26	796,300	6.08
March 27-April 10, 1945	18,000(1)	Apr	4	248,200	1.89
May 28-June 19, 1946	42,800(1)	Jun	2	410,300	3.13
April 18-August 31, 1957	13,700(1&2	2) Jun	5	1,163,200	8.88
April 13-June 11, 1958	7,720(1&2		27	365,850	2.79

(1) Flows regulated by Lake Dallas from February 1928 to November 1954, Garza-Little Elm since 1954 and Grapevine Reservoir since July 1952.

(2) Peak discharge estimated at 164,100 and 121,300 second-feet in 1957 and 1958 without existing Corps of Engineers reservoirs in operation.

EAST FORK NEAR ROCKWALL - D. A. = 840 SQ. MI.

June 15-20, 1935	64,800	Jun 1	.6	173,000	3.86
February 17-25, 1938	57,600	Feb 1		181,500	4.05
April 19-29, 1942	80,000(1&2)	Apr 2	20	259,600	5.80
May 1-5, 1944	28,500	May 3	3	102,000	2.28
February 20-25, 1945	42,800	Feb 2	22	105,300	2.35
May 29-June 5, 1946	43,600	May 3	31	204,200	4.56
April 19-June 24, 1957	43,000(2&3)	May 2	27	720,200(4)	16.08
April 30-May 5, 1958	6,000(3)	May 2	2	241,600(4)	5.40

Estimated by Corps of Engineers.
 Affected by major levee breaks.

(3) Observed flows modified by Lavon Reservoir. Estimated peak discharges without Lavon Reservoir in operation would be 54,600 and 31,800 second-feet for the 1957 and 1958 flood, respectively.

(4) Inflow computed at Lavon Reservoir.

TABLE 12 (Cont'd)

FLOOD DATA

	:	Peak	:	Date	:	Flood	vol	ume
Date of flood	:	discharge	:	of	:	passir	ng g	age
	:	(cfs)	:	peak	:	(acre-feet) :	(inches)

CHAMBERS CREEK NEAR CORSICANA - D. A.=971 SQ. MI.

1913	54,000	Dec -	(1)	(1)
November 23-30, 1940	25,400	Nov 24	121,800	2.35
April 20-30, 1942	37,400	Apr 26	243,000	4.69
April 30-May 6, 1944	48,000	May 3	191,200	3.69
March 29-April 8, 1945	32,900	Mar 31	203,000	3.92
March 29-April 8, 1945	32,900	Mar 31	203,000	3.92
April 19-May 30, 1957	23,200	May 2 ¹ 4	444,600	8.59
April 29-May 10, 1958	38,200	May 3	252,300	4.87

⁽¹⁾ Data not available.

RICHLAND CREEK NEAR RICHLAND - D. A. = 737 SQ. MI.

1913	85,000	Dec -	(1)	(1)
Nov. 23-Dec. 8, 1940	43,000	Nov 24	176,400	4.49
April 20-May 4, 1942	39,600	Apr 26	140,200	3.57
April 29-May 10, 1944	55,000	May 2	196,700	5.00
March 29-April 7, 1945	55,000	Mar 31	163,100	4.15
May 11-17, 1948	58,900	May 12	134,700	3.43
May 12-21, 1953	29,500	May 13	187,400	4.77
April 19-May 10, 1957	44,600	Apr 21	431,500	10.98
April 30-May 6, 1958	33,400	May 3	168,600	4.29

⁽¹⁾ Data not available.

WATER RESOURCE REQUIREMENTS

- 49. GENERAL. Data relative to present and prospective municipal and industrial water requirements and water quality control used in this section were taken from the report, "Water Resources Study, Trinity River Basin Texas," prepared by the Department of Health, Education and Welfare and presented as exhibit 1 in this appendix.
- 50. SURFACE AND GROUND WATER USE IN 1958.- The total water use in 1958 for municipal, industrial, and irrigation purposes was about 272.3 million gallons per day, of which about 200 million gallons per day were supplied from surface water sources and about 72.3 million gallons per day were supplied from ground water sources. In addition, it is estimated that in 1958, the adjoining coastal area to the lower Trinity River Basin used about 0.4 million gallons per day for municipal purposes, all of which was supplied from ground water sources. Also in 1958, this area is estimated to have used over 107.8 million gallons per day for irrigation, of which about 106.1 million gallons per day were from surface water sources and about 1.7 million gallons per day were from ground water sources. The municipal, industrial, and irrigation water uses during 1958 in the Trinity River Basin and adjoining coastal areas are summarized in table 13.

TABLE 13

1958 WATER USE

	ter: (MGD)		26.7	15.6	72.3		4.0	1.7	2.1	
supply	Ground water (AcFt.) : (63,500	17,500	81,000		400	1,900	2,300	
Source of supply	ater: (MGD):		176.5	23.5	200.0		0	106.1	1.901	
	Surface water (AcFt.) : (M	됬	197,900	26,300	224,200		0	119,000	119,000	
	use : (MGD) :	N WATER US	233.2	39.1	272.3	AREA USE	4.0	107.8	108.2	
	(AcFt.) : (1958 TRINITY RIVER BASIN WATER USE	261,400	43,800	305,200	1958 ADJACENT COASTAL AREA USE	004	120,900	121,300	
	use :	8 TRINITY	30.4			958 ADJACE	0			
	Industrial use (AcFt.) : (M	195	34,100	cion	ation use	Н	0	tion	ation use	
			202.8	for irrigat	and irrige		4.0	for irrigat	and irriga	
	(AcFt.): (MG)		227,300	Water used for irrigation	Total M & I and irrigation use		7000	Water used for irrigation	Total M & I and irrigation use	

- 51. RETURN FLOWS IN 1958.- Available measurements indicate that sewage return flows varying between 68 and 73 gallons per capita daily have been experienced at Fort Worth in recent years. Records of sewage measurements at Dallas indicate that recent rates of return sewage flows varied between about 74 and 80 gallons per capita daily. The lower rate was experienced during the 1952-1953 water year when water use was somewhat restricted because of the drought. Although there are monthly variations in return flow, in general the differences are not great and a seasonal variation is not clearly indicated.
- 52. SURFACE WATER QUALITY IN 1958. The quality of surface water in the Trinity River and its tributaries ranges from "very good" to "questionable" with concentrations of mineral solids varying from 100 to 1,000 parts per million. However, concentrations in excess of 500 ppm have been reported in only a few instances. The only high concentrations of mineral solids are found in the lower 40 miles of the river and result from salt water intrusion from Trinity Bay.
- 53. Organic solid concentrations present the most serious problem of surface water quality, with conditions of maximum oxygen depletion existing downstream from the Dallas-Fort Worth metropolitan area. In the reach of the river from Fort Worth to Rosser, oxidation of organic matter is retarded and septic conditions and offensive odors are usually present. The water is turbid and discolored, sludge banks may be observed at many locations and there is insufficient oxygen for fishlife to propagate.
- 54. Downstream from Rosser a steady improvement in quality takes place because of dilution by good quality water discharged by tributaries. The organic problems have almost completely disappeared at a point near the San Jacinto-Liberty County line, about river mile 100.
- 55. GROUND WATER QUALITY IN 1958. The quality of water produced from aquifers underlying the Trinity River Basin ranges from "very good" to "unsatisfactory" as indicated by mineral solids, which vary from 150 to over 5,000 ppm, with the predominating number of wells having solids less than 1,000 ppm. Chlorides range from a low of 10 ppm to a high of about 1,800 ppm with many wells showing less than 1,000 ppm. Sulfates are present in quantities ranging from a low of 10 to a high of 5,000 ppm. Only in Dallas County do the concentrations of sulfates exceed those of chlorides. Hardness is moderate throughout the entire basin, ranging between 10 and 300 ppm, with most samples containing less than 100 ppm. Of significance to industries is the presence of silica concentrations ranging from 12 to 50 ppm, necessitating higher treatment costs for many industrial uses. Water from a number of wells contains sodium concentrations ranging from 60 to 600 ppm which limits its usefulness for irrigation. Also, of significance to public health is the presence of fluorides in some areas in concentrations greater than the suggested maximum (1.0 ppm).

- 56. FUTURE WATER REQUIREMENTS. Urban and industrial areas of the Trinity River Basin are in a period of rapid economic expansion at a rate of almost one and one-half times the national average. Dallas and Fort Worth, the second and fourth largest cities in the state, have become leading manufacturing centers in the nation, ranking high in aircraft and electronics. With the anticipated continued increase in population and economic growth throughout the basin goes the need for maintenance of adequate water supply facilities and development of the surface and ground water resources of the basin to meet future demands.
- 57. Through analysis of the various needs and purposes of water resource development, both past and present, as related to the economic activities of the Trinity River Basin, broad projections to the years 2020 and 2070 have been made. In developing the requirements, recognition has been given to the efforts of a number of federal, state, and local agencies charged with the responsibility of development of the water resources of this basin. The requirements to meet the projected demands are divided into the general categories of navigation, municipal and industrial, agricultural, water quality, and recreation. The specific requirements of the Trinity River Basin are discussed in subsequent paragraphs.
- 58. WATER REQUIREMENT FOR NAVIGATION. The operation of navigation on the multiple purpose canalized Trinity River would necessitate supplying water at the head of navigation, or along the waterway, to meet the following uses and losses:
 - a. For the lockage of floating craft.
 - b. To replenish the pools for the following losses:
 - (1) Leakage through structures.
 - (2) Seepage under and around structures.
 - (3) Accidents and operating contingencies.
 - (4) Evaporation in locks and pools.

The total water requirements for operation of navigation at each lock on the canalized multiple-purpose channel to Fort Worth for the years of 1970 and 2020 were estimated. The following tabulation presents the estimated water requirements based on projected conditions of basin development and water use for 1970 and 2020 for the critical locks. Plate 21 shows the water requirements for the 1970 and 2020 conditions for each of the proposed locks.

Lock No.	2 2 •	Location (channel		equirements gation (cfs)
		mile)	: 1970	: 2020
21 (1)		360.17	114.2	144.1
19		342.51	114.8	145.9
3.5		306.31	197.3	269.5
13		286.64	260.3	356.0
7		183.92	227.8	369.2
6		147.92	104.6	483.7
5A		98.00	303.5	519.9

- (1) Lock and Dam No. 21 forms the uppermost pool at head of navigation.
- 59. MUNICIPAL AND INDUSTRIAL. The municipal and industrial water requirement projections for the years 2020 and 2070 have been determined by the Public Health Service, U. S. Dept. of Health, Education and Welfare. Their report containing a detailed analysis of water needs for the study area comprising 46 counties in and surrounding the Trinity River Basin, as based on past and present uses and economic trends is presented as exhibit 1 in this appendix. The Public Health Service's projected municipal and industrial demands are 2,080.0 million gallons per day for the year 2020 and 3,918.0 million gallons per day for the year 2070.
- 60. The above requirements are established for the Trinity River Basin only. In addition, in order to satisfy the terms of the Texas Water Commission permits issued to the Trinity River Authority and the city of Houston, 839.5 million gallons of water daily would be required for diversion from the Trinity River by the city of Houston for municipal and industrial uses in the San Jacinto River Basin.
- 61. AGRICULTURAL.- Surface water irrigation in the basin is concentrated largely in Liberty, Chambers, and Jefferson Counties where water is diverted from the Trinity River for rice production. Based on results of a joint land classification survey by the Bureau of Reclamation and the Soil Conservation Service, it is estimated that future rice irrigation in this area from water of the Trinity River will not exceed approximately 80,000 acres, the record year in the 1940-1959 period. In addition to this area in the lower basin, there are about 42,000 acres between Dallas and the Tennessee Colony Reservoir site and 49,000 acres between that site and Livingston Reservoir that are suitable for sustained permanent irrigation. These lands occur in small scattered tracts along the Trinity River. The Public Health Service has determined that these areas will require for irrigation use approximately 356 million gallons per day by the year 2020.

- 62. WATER QUALITY Efficient development of all of the water resources of the Trinity River Basin is essential to the continued growth of the area. To attain full utilization of these resources for municipal, industrial, agricultural, navigation, and recreation purposes will require abatement of the present pollution in the upper basin as well as control of future pollution throughout the area. Therefore, provision of water to maintain minimum quality conditions in the river must be made a part of the water supply plan until such time as future advances in waste treatment technology can economically provide for removal of residual pollutants before they reach the stream. The water supply plan for quality control purposes in the Trinity River Basin would come from excess dependable yields for municipal and industrial purposes in federal reservoirs, both existing and proposed, during the intervening period between construction and full utilization of the dependable yields for municipal and industrial purposes. Indications are that sufficient water resources are available in the basin to satisfy projected primary water and water quality control demands although water would have to be pumped a considerable distance up to the point of demand (Fort Worth) from the downstream reservoirs.
- 63. RECREATION, FISH AND WILDLIFE. The land areas adjacent to water developed projects located in the upper reach (Dallas-Fort Worth area) of the Trinity River Basin are sufficient at the present time to accommodate the number of people seeking water-related recreation activities. However, on the basis of the projected population for this vicinity, there will develop a substantial need for additional facilities. The number of water developed projects in the Trinity River Basin below the Dallas-Fort Worth area are very limited, and there are needs for additional projects to serve the number of people desiring to participate in water-related recreation activities. The proposed projects, when constructed, will assist materially in satisfying these needs and demands.
- 64. The tidal waters in the Gulf of Mexico and other bays also attract many visitors seeking water-related recreation activities. However, some of these individuals will alternate their water-related recreation activities between the tidal water and fresh water when fresh water impoundments are available and the travel distance is not too great.
- 65. Construction and operation of reservoirs in the comprehensive plan of improvement for the Trinity River Basin would result in the creation of productive fish habitat in the recommended Lakeview, Tennessee Colony, and other reservoirs in the system, and furnish attractive fishing in the multiple-purpose channel and cutoff sections of the Trinity River. On the other hand, big game and upland game habitat and hunting will be reduced. Also, the reduced water inflow into estuaries associated with the Trinity River will cause loss of

a highly valuable portion of marine fishing in the Galveston Bay system. The Fish and Wildlife Service estimate that a fresh water discharge of 2,000 second-feet into Trinity Bay during the period from March through October would be required to retain the estuarine fisheries.

FLOOD PROBLEMS

- 66. GENERAL. Flooding is one of the principal problems in the Trinity River Basin. Throughout the basin, the streams are meandering and in general have small channel capacities in proportion to the areas drained. Consequently, floods are experienced at frequent intervals throughout practically the entire river system.
- 67. PAST FLOODS. According to historical information, major floods occurred in the vicinity of Dallas and Fort Worth in 1866, 1884, and 1889; however, little detailed information is available on those floods outside the Dallas-Fort Worth area. Data concerning the major basin storms and the resulting floods have been presented previously in this appendix (paragraphs 34 through 48).
- 68. EXISTING FLOOD-CONTROL PROJECTS. Local interests have taken some steps toward solving the flood problem in localized areas within the basin, principally by construction of levees and floodway improvements (see paragraph 11). In recent years, the Federal Government has provided betterments to some of the locally constructed improvements and has constructed additional flood-control works which have materially increased the protection from floods (see paragraphs 8 and 9). The flood-control work to date has been primarily in the portion of the basin upstream from Richland Creek, the area in which the most extensive concentrations of urban and agricultural developments in the Trinity River Basin are located. These projects have served to control flood runoff and reduce flood discharges from an area on which the most damaging floods of record in the basin have been generated. Major floods have on occasion been generated in the basin area below the confluence of Richland Creek and the main stem of the Trinity River, but records show that the magnitude of such floods has not been as great as those which originate upstream. Runoff from the lower basin, however, augmented by that from the upper basin, results in an increase in volume and duration of flood flows as they progress downstream. Existing flood-control works afford a high degree of protection to some areas of the basin from damages which would result from the recurrence of floods equal in magnitude to those of record. The effectiveness of those works was demonstrated during the 1957 flood in the upper reaches of the basin during which the operation of the existing flood-control projects is credited with prevention of widespread damages.
- 69. Local soil conservation districts, with the assistance of the Soil Conservation Service, have instituted and now have in progress an accelerated land treatment program. Approximately 28 percent of the agricultural land of the basin is adequately treated at this time, and another 10 percent is partially treated, lacking one or more

practices. In addition to, and supplementing this program, construction of floodwater retarding structures in the creek watersheds will serve to reduce flash runoff and sediment production. However, uncontrolled releases from these structures will occupy downstream channels for prolonged periods and thus limit controlled releases from other reservoirs.

- 70. CRITICAL AREAS. Extensive urban development, which has taken place in the lowland areas adjacent to the Trinity River and its tributaries, was accelerated by the prolonged drought of 1950-1957 and an erroneous impression as to the degree of protection afforded by the upstream projects built during and subsequent to the drought period. Damages which were experienced during the 1957 flood clearly emphasized the need for additional flood-control works for the protection of these newly-developed areas, as well as other portions of the basin which were not previously afforded adequate protection. Critical urban areas requiring additional flood protection are on the West Fork between Fort Worth and Dallas, the Elm Fork between Dallas and Carrollton, the Trinity River immediately below Dallas and at Liberty, and Duck Creek at Garland. Extensive damages are also sustained in agricultural areas along the main stem of the Trinity River below Dallas and on the Elm Fork watershed between Carrollton and the Garza-Little Elm and Grapevine Reservoirs.
- 71. CHANNEL DEFICIENCY Floods experienced subsequent to the completion of the Corps of Engineers reservoir projects in the upper Trinity River Basin revealed that the problem of inadequate channel capacity exists on the Trinity River and tributaries. The problem of insufficient channel capacities was particularly evident during the April-June 1957 flood, when the Trinity River Basin experienced heavy rainfall almost daily. Recent encroachments, together with certain channel deficiencies that previously existed, have limited flood-control releases from existing upstream reservoirs to such an extent as to materially reduce their effectiveness for providing flood protection. Therefore, in order to provide an effective plan for flood control in the basin, channels should be of sufficient capacity to provide a reasonable degree of protection against floods originating on the uncontrolled area below upstream reservoirs. As a further requirement, channels should be of sufficient capacity to permit passage of uncontrolled releases from downstream reservoirs together with regulated flood releases from Corps of Engineers reservoirs at rates of sufficient magnitude to permit evacuation of stored floodwaters in a reasonable period of time after downstream flooding has ceased.

PLAN OF IMPROVEMENT

- 72. GENERAL. The projects considered for addition to the authorized plan of improvement for the Trinity River Basin as set forth in Appendix I, Project Formulation, consists of the following principal features:
- a. A multiple-purpose channel extending from the Houston Ship Channel in Galveston Bay to Fort Worth and including 23 navigation locks and 18 navigation dams;
 - b. ten multiple-purpose reservoir projects;
 - c. twelve reservoir projects primarily for water conservation;
 - d. one reservoir primarily for flood control; and
 - e. eleven local flood protection projects.

Existing and authorized projects and the projects considered for addition to the authorized plan for the Trinity River Basin are listed in table 1^{14} and are shown on plate 13.

 $\label{eq:table_lambda} \mbox{Table } 1^{l_{\rm A}}$ PROJECTS CONSIDERED IN FLAN OF IMPROVEMENT

		tion	
Name of project	: Stream	: River mile	Purpose
1. CHANNEL-MULTIPLE PURPOSE			
a) Racommended New Project:			
(1) Houston Dhip Channel to Fort Worth	Trinity River	0542.0	Navigation and Flood Control
2. CHANNEL-NAVIGATION			
a) Existing Project: (1) Houston Ship Channel to Anahuac	Trinity River	0.000	World and a single
(1) Authorized Project;	Trintel Wiver	0 23.2	Navigation
(1) Analuge to Liberty	Trinity River	23.2 48.9	Navigation
3. RESERVOIR-MULTIPLE PURPOSE			
a) Existing Projects:			
(1) Benbrook (2) Grapevine	Clear Fork Denton Creek	15.0	Flood Control and Navigation
(3) Garza-Little Elm	Elm Fork	11.7 30.0	Flood Control, Navigation, and Water Conservation Flood Control and Water Conservation
(4) Lavon	East Fork	55.9	Flood Control and Water Conservation
(5) Mayarro Mills (under construction)	Richland Creek	63.9	Flood Control and Water Conservation
b) Authorized Projects:		0,0	11000 CONDICT CARE WASCI CONDUCTATION
(1) Bardwell	Waxahachie Creek	6.0	Flood Control and Water Conservation
e) Recommended New Projects:			The state of the s
(1) Tennessee Colony	Trinity River	339.2	Flood Control, Navigation, Water Conservation, Recreation,
			and Fish and Wildlife
(2) Lakeview	Mountain Creek	7.2	Flood Control, Water Conservation, Recreation, and Fish
(-) - (-) (-)			and Wildlife
(3) Lavon (enlargement) (1)	East Fork	55.9	Water Conservation and Recreation
(4) Wallisville (1)	Trinity River	3.9	Salinity Control, Navigation, Water Conservation, Recreation
(5) Aubrey (2)	Elm Fork	60.0	and Fish and Wildlife
(2) medial (c)	MAIN AVAIN	.00.0	Flood Control and Water Conservation (2)
W. RESERVOIRS FRIMARILY FOR CONSERVATION (3)			
a) Promosed New Projects:			
(1) Richland Creek	Richland Creek	5.2	Water Conservation
(E) Tehuacana	Tehuacana Creek	11.2	Water Conservation
(3) Boyd	West Fork	604.7	Water Conservation
(4) Upper Keecht	Upper Keechi Cre		Water Conservation
(5) Hurricane	Hurricane Bayou		Water Conservation
(6) Lower Keechi (7) Bedins	Lower Keechi Cre- Bedias Creek		Water Conservation
(8) Harmons	Harmons Creek	19.2	Water Conservation Water Conservation
(a) 0m11	Gail Creek	25.3	Water Conservation
(10) Mustang	Mustang Creek	21.5	Water Conservation
(11) Caney	Caney Creek	7.7	Water Conservation
(12) Long King	Long King Creek	22.9	Water Conservation
5. RESERVOIR FRIMARILY FOR FLOOD CONTROL			
(1) Roanoke (4)	Denton Creek	31.4	m - 1 a - 1 (1)
(1) notable (4)	Denton Creek	71.4	Flood Control (4)
b. LOCAL FLOOD PROTECTION PROJECTS			
a) Existing Projects:			
(1) Fort Worth Floodway	West Fork	551.3564.7	Local Flood Protection
	Clear Fork	0 1.6	
(2) Dillas Floodway	Trinity River	497.4505.5	Local Flood Protection
	West Fork	505.5508.7	
V. S. Albert and Provident	Elm Fork	0 3.5	
Authorized Projects:	Hard Book	not a see t	
(1) Fort Worth Floodway Extension (Part I) (2) Big Fossil Creek	West Fork	564.7570.4	Local Flood Protection
(2) Big Fossii treek) Recommended New Frojects:	Big Fossil Creek	0 3.3	Local Flood Protection
(1) Fort Worth Floodway Extension (Part II) (1)	Clear Fork	1.6 10.4	Local Flood Protection
(2) West Fork Floodway	West Fork	505.5551.5	Local Flood Protection
(3) Elm Fork Floodway	Elm Fork	0 29.4	Local Flood Protection
	Denton Creek	0 11.1	THE PARTY OF THE P
(A) Dallas Floodway Extension		487.7498.1	Local Flood Protection
(5) East Fork Channel Improvement (1)	East Fork	0 31.8	Local Flood Protection
		10 1 10 0	Local Flood Protection
(b) Duck Creek Channel Improvement (7) Liberty Floodway	Duck Creek Trinity River	10.4 17.5 34.0 44.5	BOCKL FLOOU FIDEGUION

(1) Freviously recommended.

⁽²⁾ The flood-control storage in Aubrey Reservoir would replace a comparable amount of flood-control storage which would be reallocated to conservation purposes in Garza-Little Elm Reservoir.

⁽³⁾ These reservoirs will also be considered for flood control, as well as water supply, water quality, recreation and fish and wildlife purposes, when the needs become imminent.

^(%) The flood-control storage in Roanoke Reservoir would replace a comparable amount of flood-control storage which would be reallocated to conservation purposes in Grapevine Reservoir.

73. WATER SUPPLY. The projected water supply requirements for the Trinity River Basin to satisfy the needs for municipal, industrial, non-municipal use, water quality control, navigation, irrigation, and exportations have been estimated to be 3,433 million gallons per day by year 2020 and 5,187 million gallons per day by year 2070, as shown in the following tabulation:

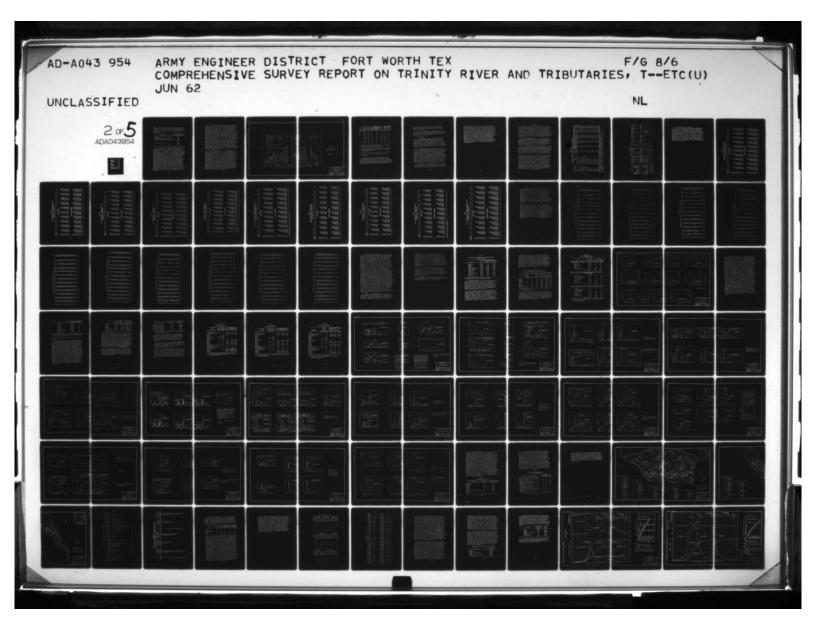
WATER REQUIREMENTS (Million Gallons Per Day)

Sub-Basin:	Municipal and Industrial		quality:			Exports	Total
			Year 202	0			
Upper Middle Lower Total	1,513(1) 227 340 2,080	15 3 2 20	80(2) 0 0 80	0 0 <u>57</u> 57	69 65 222 356	0 0 840 840	1,677 295 1,461 3,433
			Year 207	0			
Upper Middle Lower Total	2,797 435 686 3,918	11 4 16	0(2)	0 0 57 57	69 65 222 356	0 0 840 840	2,877 504 1,806 5,187

⁽¹⁾ Includes 40 MGD yield from Aubrey Reservoir for interim use as water quality control.

74. The existing, under construction, and authorized reservoirs with storage for water supply for municipal and industrial purposes together with the importations would produce a water supply of 1,343.4 million gallons per day. The Roanoke (including modification of Grapevine Reservoir), Aubrey (including modification of Garza-Little Elm Reservoir), Lakeview, and Tennessee Colony multiple-purpose reservoir projects which are recommended for authorization in this report plus the previously recommended enlargement of Lavon Reservoir would produce a water supply of 453.1 million gallons per day. Thirteen additional potential reservoir projects have been recommended for inclusion in the long-range plan of development for the Trinity River Basin primarily in the interest of water supply. These reservoirs were formulated on the basis of developing the surface water resources of the Trinity River Basin to the maximum practical extent. The construction of the longrange projects has been considered as a phase development which would be coordinated with the needs of the basin in such a manner as to permit

^{(2) 80} MGD for water quality control would be converted to water supply as the need develops.



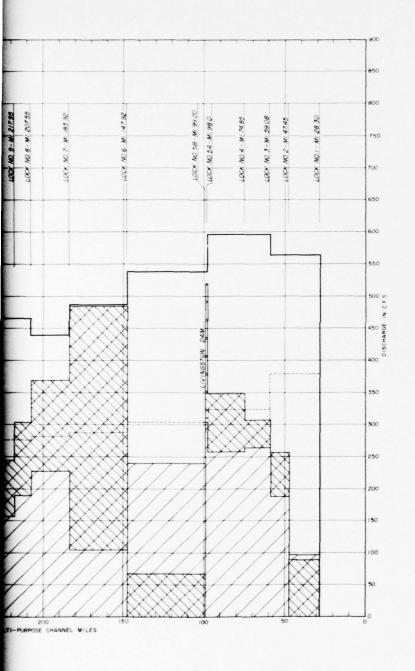
timely construction to provide additional water supply as the needs develop. The thirteen potential reservoirs would produce a water supply of 680.4 million gallons per day. The system of reservoirs included in the comprehensive plan together with importations would furnish a water supply of 2,476.9 million gallons per day as summarized below:

Reservoirs	Water supply (Million gallons per day)
Existing, Under Construction, Authorized Importations Previously recommended for authorization Recommended for authorization in this rep	1,163.4 180.0 42.7 port 410.4
Sub-total	1,796.5
Potential long-range projects	_680.4
Total	2,476.9

75. Water supply from reservoirs which are existing, under construction, authorized, and recommended for authorization in this report together with a nominal use of ground water and return flow would satisfy the projected demands in all segments of the basin until about 2000 to 2010. An additional supply of approximately 1640 and 3390 million gallons per day would be required to satisfy the projected water requirements for years 2020 and 2070 respectively. An analysis of the available water supply in the basin from additional reservoirs in the long-range plan, ground water and return flow revealed that the potential of these resources may be sufficiently developed to satisfy the additional requirements of the basin to year 2070. Unquestionably the expansion of ground water use beyond the present 72 million gallons per day and the use of return flows will progressively increase throughout the projected period of basin development. Other than to conclusively establish the fact that ultimate water requirements will necessitate the maximum practical development of these two resources to meet in-basin demands, no definitive basis is available to predict just when these resources would be scheduled into the overall development. Alternate resources of supply from adjacent basins to the north and east could be imported if in the future local interests decided to utilize such resources rather than to use additional ground water or return flow. Generally, the development and use of these water resources will progress in consonance with the changing economic conditions and areal development of the basin and with the distribution, availability and quality of these water resources.

76. Development of the Lakeview Reservoir project would afford a source of water supply to satisfy the immediate needs of local interests. The water supply of 291 million gallons per day from the Tennessee Colony Reservoir would serve a dual purpose - initially 80 million gallons would be used for water quality control in the upper basin and the remainder would be available as a source of municipal and industrial water supply for the middle basin. At about year 2020, as the need for municipal and industrial water supply increases in the upper basin, a transfer would be effected in the area of use for the remaining 211 million gallons per day of the Tennessee Colony water supply. It is anticipated that construction of the eight long-range reservoir projects in the middle basin would be phased with the gradual transfer of the Tennessee Colony water supply with construction of certain projects starting around the turn of the century so that the demands of the middle basin may continue to be fully satisfied. Initially the water supply from the Aubrey Reservoir would be used in the interest of water quality control. However, as the need for municipal and industrial water supply develops, a conversion from water quality control to water supply for municipal and industrial use would be made. There is no immediate demand for the additional water supply provided by the Roanoke Reservoir; however, it is considered that preservation of this project by acquisition of the land required at this time is desirable and economically justified. The actual project would not be constructed until the needs for the storage developed. The 13 potential projects included in the long-range plan to satisfy future requirements would be considered for authorization after detailed investigations to determine the full scope and purposes that would be justified at that time.

77. NAVIGATION WATER SUPPLY. The net water requirements for navigation based on evaporation and other losses through the lowest lock at Wallisville Reservoir would be 95.7 and 88.2 second-feet in the years 1970 and 2020, respectively. However, in order for the system to become operational, it will require a supply of water at the head of navigation of 114.2 second-feet in 1970. For planning purposes in connection with this study, the Public Health Service was requested to make an analysis of the future net return flows in the Trinity River for the years 1970 and 2020. The studies made by the Public Health Service were premised (at the request of the Corps) on the conditions that the proposed modified plan for the Trinity River would be considered as operational by the year 1970 and that return flows would be considered as the only available source of supply without allowances for any local runoff from the uncontrolled drainage areas. The Public Health Service took into account the projected conditions of basin development and water use expected for the years 1970 and 2020. The following tabulation presents the navigation water requirements as estimated by the Corps and net available return flows based upon the Public Health Service studies for the 1970 and 2020 conditions at the critical locks. Plate 21 shows the water requirements and return flows for the 1970 and 2020 conditions at each of the proposed locks.



LEGEND

NAVIGATION REQUIREMENTS (1970) ----- RETURN FLOW (1970) * NAVIGATION REQUIREMENTS (2020)

- RETURN FLOW (2020)

★ Includes releases from navigation storage in Benbrook and Grapevine Reservoirs

TRINITY RIVER AND TRIBUTARIES, TEXAS TRINITY RIVER NAVIGATION AND FLOOD CONTROL CHANNEL

RETURN FLOWS AND NAVIGATION REQUIREMENTS-1970 AND 2020

SCALE AS SHOWN

SCALE AS SHOWN

U.S. ARMY ENGINEER DISTRICT, FORT WORTH

JUNE 1962

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Lock Number	: Lock : :location: :(channel: r: mile) :	ment	:Return :	conditions Supply (cfs) Reservoir : releases(2):	Total	:Require-	flow
21(4)	360.17	114.2	97 (17.8	114.8	144.1	229
19	342.51	114.8	97 🗸	17.8	114.8	145.9	229
15	306.31	197.3	226	22.3	248.3	269.5	510
13	286.64	260.3	238	22.3	260.3	356.0	479
7	183.92	227.8	259	14.5	273.5	369.2	7474
6	147.92	104.6	264	14.5	278.5	483.7	486
5 A	98.00	303.5	289	14.5	303.5	519.9	539

- (1) Based on data furnished by Public Health Service, Region VII, Department of Health, Education and Welfare.
- (2) Releases from the navigation storages of Benbrook and Grapevine Reservoirs would be made at such rates as would be necessary to meet the requirements.
- (3) Waterway will reach its full traffic capacity by the year 2015.
- (4) Lock and Dam No. 21 forms the uppermost pool at the head of navigation.

78. The data presented in the preceding tabulation reveal that in the year 2020, return flows would be sufficient to meet the navigation requirements, but that in 1970 there would be several critical areas where the water supply from return flow alone would not quite satisfy the requirements. However, it is estimated that the return flows would furnish sufficient water to meet the navigation requirements by the year 1973. In the interim (1970-1973), return flows and

local runoff from the uncontrolled areas would be supplemented by releases from the navigation storages of Benbrook and Grapevine Reservoirs at such rates as would be necessary to meet the requirements at the critical locks.

79. From an overall analysis of the navigation aspects of the Trinity River plan with respect to the water requirements and available sources of supply to satisfy these requirements, it is concluded that sufficient water resources are available to permit navigation on the Trinity River to Fort Worth by year 1970.

80. WATER QUALITY .-

- a. Ground Water. The quality of water of the aquifers underlying the Trinity River Basin will not change materially if reasonable steps are taken to avoid contamination. Disposition of liquid wastes by means of sub-surface injection wells and in surface ponds or lagoons, and the abandonment of oil wells should be closely supervised and suitable regulations enforced to insure the provision of adequate facilities and suitable operations. In the area bordering the coast, saltwater encroachment is, and will continue to be, a hazard which can be minimized by the decrease in the rate of withdrawal from inland wells.
- b. Surface Water .- Abatement of the present pollution problem on the West Fork and Trinity River from Fort Worth downstream to Rosser is essential to attain full utilization of the water resources of the region for municipal, industrial, agricultural, navigation, and recreation purposes. Although most of the waste treatment plants in the area discharging into the Trinity River Basin are operating efficiently within their design capacities, insufficient tributary dilution and reaeration cause anaerobic conditions to exist. Therefore, provision of water to maintain minimum quality conditions in the river must be made a part of the water supply plan until such time as future advances in waste treatment technology can economically provide for removal of residual pollutants before they reach the stream. The water supply plan for quality control purposes would be to utilize excess dependable yield from Tennessee Colony Reservoir and other federal reservoirs in the basin until such time as these yields were needed to meet the requirements for municipal and industrial purposes.
- 81. FULFILLMENT OF FLOOD-CONTROL REQUIREMENTS. The recommended plan of improvement for the Trinity River Basin presented in paragraph 72 would provide a high degree of flood protection for the Trinity River and its principal tributaries. The system of major multiple-purpose

and flood-control reservoirs in the plan would control flood flows from approximately 16 percent of the area above Fort Worth, 50 percent of the area above Dallas, 47 percent of the area above Rosser, and 72 percent of the area above Liberty. The local protection projects in the plan would provide flood protection to areas in the flood plains of the Clear Fork, West Fork, Elm Fork, and Trinity River in and adjacent to the cities of Fort Worth and Dallas, to areas in the flood plain of Duck Creek at Garland, and to areas in the flood plain of the Trinity River at Liberty. The recommended multiple-purpose channel would provide sufficient channel capacity to permit passage of flood flows from the uncontrolled areas, uncontrolled releases from reservoirs downstream from Corps of Engineers reservoirs, and regulated flood releases from Corps of Engineers reservoirs at rates of sufficient magnitude to permit evacuation of the flood-control storage in a reasonable period of time. The multiple-purpose channel would, therefore, afford some degree of protection against floods originating on the uncontrolled area below the upstream reservoirs, and at the same time increase the effectiveness of the flood-control storage in the upstream reservoirs.

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RESERVOIRS

- 82. GENERAL. In the Trinity River Basin there are 24 major reservoirs, either in operation, under construction, or authorized which contain conservation storage and have individual total storage capacities of more than 5,000 acre-feet as shown in tables 2 and 4. Of these 24 reservoirs, 6 are Corps of Engineers projects and 18 are non-federal projects. The total conservation storage contained in these reservoirs is 4,191,350 acre-feet. The location of the reservoirs is shown on plate 13, and additional information pertinent to the reservoirs is given below. There are also 79 reservoirs in the basin with individual total storage capacities of less than 5,000 acre-feet. These reservoirs contain a total of about 41,000 acre-feet of conservation storage. In addition, there are about 66,500 farm ponds with an average storage capacity of almost 2 acre-feet.
- 83. CORPS OF ENGINEERS RESERVOIRS. The 6 Corps of Engineers reservoir projects mentioned above are: the Benbrook, Grapevine, Garza-Little Elm, and Lavon Reservoirs which are in operation; the Navarro Mills Reservoir which is under construction; and the authorized Bardwell Reservoir which is in the preconstruction planning stage. These six reservoirs contain a total of 852,450 acre-feet of conservation storage, of which 97,500 acre-feet are reserved for navigation requirements. Pertinent data for these reservoirs are given in table 2.
- 84. NON-FEDERAL RESERVOIRS. The 18 non-federal reservoirs referred to above are as follows: Amon Carter, Bridgeport, Eagle Mountain, Lake Worth, Arlington, Mountain Creek, Marine Creek, Weatherford, North Lake, White Rock, Lake Trinidad, Livingston, Lake Anahuac, Forney, Lake Terrell, Cedar Creek, Waxahachie, and Lake Halbert. Of these, 15 are in operation and 3 Livingston, Forney, and Cedar Creek are under construction. These non-federal reservoirs contain a total of 3,338,900 acre-feet of conservation storage. Pertinent data for these reservoirs are given in table 4.
- 85. The plan of improvement for the Trinity River Basin recommends construction of 5 federal reservoirs at this time: Lakeview Reservoir on Mountain Creek; Roanoke Reservoir on Denton Creek; Aubrey Reservoir on Elm Fork of the Trinity River; Tennessee Colony Reservoir on the Trinity River; and the previously recommended Wallisville Reservoir on the Trinity River. Also included in the recommended plan of improvement is the previously recommended enlargement of the existing Lavon Reservoir. With the construction of Roanoke and Aubrey Reservoirs, it is proposed to reallocate storages in the existing Grapevine and Garza-Little Elm Reservoirs to provide additional conservation storage. Projects included in the plan of improvement as future reservoirs but not recommended at this time are Boyd, Richland Creek, Tehuacana, Upper Keechi, Lower Keechi, Hurricane, Bedias, Harmons, Gail, Mustang, Caney, and Long King Reservoirs. Pertinent data for reservoirs recommended and proposed for inclusion in the long range plan are shown in tables 15 and 16 and the location of each is shown on plate 13.

TABLE 15

RESERVOIRS PROPOSED BUT NOT RECOMMENDED AT THIS TIME

Reservoir	Stream	: River : mile	:Contributing: Storage capacity (acre-feet)(1) :2020 : drainage : : : : : :Yiel : : :Yiel : : : : : : : : : : : : : : : : : : :	<pre>3: Storage c : : :):Sediment:C</pre>	apacity (ac	re-feet)(1) : : Total	:2020 :Yield :(cfs)
Boyd	West Fork Trinity	7.409	1,707	39,200	000,009	639,200	49(2)
Richland Creek	Richland Creek Richland Creek	5.2	47	45,200	1,000,000	1,045,200	262
Tehuacana	Tehuacana Creek	11.2	356	12,800	282,500	295,300	(109.3)
Upper Keechi	Upper Keechi Creek	11.0	981	6,500	125,000	134,500	(20°.7)
Lower Keechi	Lower Keechi Creek	8.9	162	3,000	170,000	173,000	39
Hurricane	Hurricane Bayou	7.0	ठ	1,900	150,000	151,900	12 (2.7)
Bedias	Bedias Creek	19.2	327	16,700	360,000	376,700	(17.5)
Harmons	Harmons Creek	10.5	L11	1,100	78,000	79,100	9891
Gail	Gail Creek	25.3	정	1,900	168,000	169,900	ξ ξ ξ
Mustang	Mustang Creek	23.7	₹	1,700	156,000	157,700	33
Caney	Caney Creek	7.7	47	1,600	134,000	135,600	(25,2)
Long King	Long King Creek	22.9	57	2,200,	184,000	186,200	(34.2)

These reservoirs will also be considered for flood control, as well as water supply, water quality, recreation and fish and wildlife purposes, when the needs become imminent.

Net yield from conservation storage (all flows except flood flows assumed as passing through the reservoir). (5)

NOTE: Figures shown parenthetically in yield column are 2020 yields in million gallons daily.

TABLE 16

PERTINENT DATA - RECOMMENDED RESERVOIRS

			:Contrib.:		Net stora	Net storage (acre-feet	et)	: 2020 :		Pertinent el	Pertinent elevations - (ft-ms]	ft-mel)	1
Reservoir	: Stream	:River:	D.A. :			: Flood		: Yield:	Stream-	Mield: Stream -: Conserva -: Top of flood: Design water: Top of	Tood Tood	eston water	Ton of
	:	:mile :(s	(sq.mi.):	Sediment	sq.mi.):Sediment :Conservation:	1: Control	: Total	: (cfs):	peq	tion :	control	Surface	
								(3)					
Lakeview	Mountain Cr.	7.2	272	45,600	306,400	136,700	0 488,700	47	453.0	518.0	528.0	5.38. A	chh.
Roanoke	Denton Cr.	35.0		26,200	0	223,70		. 0	534.0		610.0	606 7	63
Grapevine (1)	Denton Cr.	11.7		16,000				, 4	0	0 755	0.670	1.000	0.100
Anhrey	FIN POPE	0		27 800	000 000				0.77	220.0	200.0	503.9	200.0
C	TOTAL TOTAL	36	200	200					528.0	625.5	635.0	640.3	0.949
Carza-Little Kim(I) Kim Fork	EIM FORK	30.0	1,658	40,700		331,60	r,	118	435.0	522.0	532.0	556.6	560.0
Lavon (enlarged)(2) East Fork	East Fork	55.9	777	47,800		275,60	00 685,700	121	433.0	489.0	501.0	507.1	5.0.5
Tennessee Colony	Trinity Riv.	339.5	12,687	190,000	1,032,500	2,144,300	6	450	191.0	262.5	285.0	8.700	305.0
Wallisville (2)	Trinity Riv.	3.0	17,760	12.800	42.900					-		2 4	0.00
										2		5	0
		: Sp	: Spillway design flood	sign floc	pq :	Spillway	: FIO	Flood-control outlet works	outlet	works	-MO-I	Tow-flow outlets	
		: Pea	k : Peak		:Net length	1 : Gates - No.:	No.			Intake invert		Inta	Intake invert
Reservoir	: Stream	: Infl	:inflow:outflow: Volume	w: Volume	e : at crest	: and	જ 	: Contro	-	elevation	: No. & size	•	el evet fon
		: (cfs)	(cfs): (cfs	: (cfs) :(acft.):	t.): (feet)	: size	: size			(ft-msl)			ft-ms])
Lakeview	Mountain Cr.				413,400 120	3-40' x 28'	28, 1-12,0	2-5.5 X12	2' gates	0.094	None		
Roanoke	Denton Cr.	325,6	000,795 00		780,000 280	7-40' x 35'	35' 1-15'8	3-4.5'x15'	5' gates		None		
Grapevine (1)	Denton Cr.	375,000			900 2009	None	1-13.0	2-6.5 x13		475.0	2-30" @ conduits		500.5
Aubrey	Elm Fork	483,1				9-40' x 35	35' None	r.			2-36" ¢ con		0.050
Garza-Little Elm(1)	Elm Fork	856,900	35	001,411,5 0		None	1-16.4	3-6.5'x13'	3' Fates	1448.0	2-60" g conduits		181.0
Lavon (enlarged)(2)	East Fork				0	12-40' x 28	28' None				5-36"0 con		53.0
Tennessee Colony	Trinity Riv.	951,800	000 556,000	0 10,033,400	044 004	11-40' x 35		4-			4-3'x6' sluices		00.00
Wallisville (2)	Trinity Riv.		00 200,000		900 (100	12 × 101-1					None		
					00)	Mond							
					1001001	011011							

(1) Projects based upon exchange of storage after completion of Roanoke and Aubrey Reservoirs.

(2) Previously recommended.

(3) 2020 yields in million gallons daily as follows: Lakeview, 30.4; Romoke, 0; Grapevine, 42.0; Aubrey, 75.0; Garza-Little Elm, 76.3; Lavon (enlarged), 78.2; and Tennessee Colony, 290.8.

86. AREA AND CAPACITY OF THE RESERVOIRS. - The area and capacity of the reservoirs were determined from available topographic maps of the reservoir sites. Lake Dallas, a local interest water supply project inundated by Corps of Engineers Garza-Little Elm Reservoir, was resurveyed in 1952 and these data incorporated in the determination of the area and capacity of Garza-Little Elm Reservoir. The Corps of Engineers resurveyed Lavon, Garza-Little Elm, and Grapevine Reservoirs in 1959, 1960, and 1961, respectively. The results of the resurvey of Lavon Reservoir indicated the capacity of the reservoir in 1959 was essentially the same as the original area and capacity tabulations. The analysis of this resurvey on the other two reservoirs has not been completed at this time. Tabulations of the initial area and capacity data for Benbrook, Lakeview, Roanoke, Grapevine, Aubrey, Garza-Little Elm, Lavon, Bardwell, Navarro Mills, and Tennessee Colony Reservoirs are given in tables 17 through 26.

TABLE 17

AREA AND CAPACITY DATA - BENEROOK RESERVOIR RIVER MILE 15.0 - CLEAR FORK TRINITY RIVER Drainage Area = 433 sq. mi.

	0.		0 52 0	38,2	989	2,460	3,320	4, 330 5,690	6,950	8,230	9,950		0	009	2,720	8,990	27,050	70,530	108,570	159,020	298,530	389,770	
	80		25	340	048	2,390	3,240	2,560	6,820	8,190	9,780		95	520	2,360	8,120	29,480	67,250	104,240	153,390	290,280	379,900	
	7		19	308	790	2,310	3,150	5,430	6,690	8,050	9,620		75	071	2,040	7,300	18,010	64,060	100,050	147,890	282,160	370,200	
	9		16	560	730	2,240	3,070	5,300	6,560	7,910	9,450		57	380	1,760	6,550	16,640	60,950	95,990	142,520	274,180	360,670 463,870	
33 sq. mi.	5	SE	13	230	680	2,170	2,980	5,170	0,440	7,770	9,280	E-FEET	24	330	1,520	5,040	30 100	57,930	92,060	137,280	266,330	351,300	
e Area = 4	#	AREA IN ACRES	13	500	620	2,080	2,890	5,050	6,310	7,630	9,120 10,860	CAPACITY IN ACRE-FEE	30	280	1,300	5,190	30 290	55,000	88,250	132,170	258,630	342,100	
Urainag	е	ĄI	o d	282	570 ר	1,990	2,800	3,080	6,190	7,500	8,960 10,680	CAPAC	50	240	011,1	4,590	13,020	52,150	84,530	127,190	251,070	333,060	
	2		7	150	520	1,986	2,710	4.790	0,070	7,360	10,490		12	210	950	4,050	26, 330	49,460	80,890	122,340	243,640	324,190 420,410	•
	1		2,5	48	0.00	1,80	2,620	4.660	5,950	7,220	8,630 10,300		9	175	810	3,560	24 470	16,740	77,350	117,620	236,360	315,480	
	0		ma	88	410 050	1,7.0	2,530	3,410	5,820	7,080	8,470 10,120		Q	145	700	3,120	27.00	44,170	73,900	113,030	229,210	306,930	
	El. in: ft-msl:		620 620	640	650	029	889	28	770	720	730		620	630	049	650	000	289	069	90,5	720	730	

TABLE 18

AREA AND CAPACITY DATA - LAKEVIEW RESERVOIR SITE RIVER MILE 7.2 - MOUNTAIN CREEK Drainage Area = 272 sq. mi.

6		2,270 3,900 1,700 12,610 16,040 25,460		2,380 18,330 49,010 96,570 162,860 250,410 361,945 504,540 690,520
8		800 2,120 3,730 5,450 7,480 9,610 12,300 15,650 20,850		1,485 16,140 45,200 91,030 155,270 240,690 349,490 488,695 669,445
7		550 1,980 3,560 7,260 9,400 11,990 15,260 20,330		810 14,090 41,550 85,670 147,900 231,180 337,345 473,240 648,885 874,750
9		300 3,390 3,390 7,040 11,690 11,690 14,910 19,800		385 12,180 38,080 80,480 140,750 221,890 325,505 458,155 628,790 850,270
5	ACRES	140 1,710 3,220 4,920 6,820 11,400 11,560 19,200	ACRE-FEET	165 34,770 34,770 173,820 212,810 212,810 313,960 443,420 609,290 826,190
4	AREA IN A	43 3,060 4,750 6,600 8,750 11,110 14,230 18,530	CAPACITY IN AC	22 8,760 31,630 70,640 127,110 203,940 302,705 429,025 590,425 802,520
3		0 2,450 2,900 4,580 6,400 8,520 10,840 13,900 17,900	CAPA	0 28,650 28,650 65,980 1120,610 195,300 291,730 419,960 572,210
Ci		1,330 2,740 4,410 6,210 8,310 10,580 13,570 17,360		5,850 25,830 61,480 1114,310 186,890 281,020 401,225 554,600
1		1,210 2,580 4,240 6,000 8,110 10,320 13,250 16,890 22,190		4,580 23,170 57,160 108,200 178,680 270,570 387,81,5 537,455 734,030
0		1,103 2,416 4,074 5,815 7,910 10,079 12,939 16,449 21,766		3,430 20,675 53,000 102,295 170,670 260,370 374,720 520,785 712,050
El. in ft msl		450 460 470 480 500 510 520 540 550		1450 1460 1460 1460 1500 1500 1500 1500 1500 1500 1500 15

TABLE 19

AREA AND CAPACITY DATA - ROANOKE RESERVOIR SITE RIVER MILE 32.0 - DEMION CREEK Drainage Area = 604 sq. mi.

El. in: ft-msl:	0	1	2	m	4	5	9	7	80	6
				AREA	A IN ACRES					
530					0	1	8	4	8	10
540	12	18	25	28	30	35	35	04	43	L+1
550	20	13	52	53	54	56	58	19	62	63
260	1 9	8	140	210	300	405	240	655	725	8
570	990	1,090	1,180	1,200	1,335	1,400	1,480	1,570	1,690	1,810
580	1,994	2,130	2,400	2,750	3,175	3,000	3,880	4,125	4,320	4,485
289	4,620	4,780	4,925	5,060	5,180	5,300	5,420	5,550	5,650	5,770
009	5,905	6,015	6,135	6,250	6,370	6,500	6,650	6,820	7,030	7,250
019	19467	7,710	7,960	8,200	8,460	8,720	8,990	9,230	6,480	9,720
620	0766	10,180	10,440	10,700	10,990	11,250	11,490	11,70	11,930	12,140
630	12,350	12,570	12,780	13,000	13,210	13,430	13,640	13,860	14,070	14,290
650	16,500	14,710	14,930	15,140	15,360	15,570	15,790	16,000	16,220	16,430
				CAPACITY	Y IN ACRE-FEET	FEET				
630					C	C	0	ır		00
270	17	56	78	105	130	160	500	240	380	350
550	370	450	014	530	280	630	069	750	SE C	870
560	950	1,010	1,130	1,300	1,560	1,910	2,380	2,980	3,670	084,4
570	5,430	6,470	7,610	8,825	10,125	11,490	12,930	14,450	16,085	17,835
580	19,740	2,800	24,005	26,040	59,600	32,990	36,730	40,730	44,955	49,355
289	53,910	58,610	63,400	68,455	73,575	78,815	84,175	89,660	95,260	100,970
009	106,805	112,770	118,840	125,035	131,345	137,780	144,355	151,090	158,015	165,155
019	172,510	180,100	187,935	196,015	204,345	212,935	221,790	230,900	240,255	249,855
620	259,685	269,745	280,055	290,625	301,520	312,640	324,010	335,610	347,430	359,465
630	371,710	384,170	396,845	409,735	452,840	436,160	449,700	463,445	477,410	491,590
049	505,985	520,590	535,410	550,445	565,695	581,160	296,840	612,735	628,845	645,170
059	011,199									

TABLE 20

AREA AND CAPACITY DATA - GRAPEVINE RESERVOIR RIVER MILE 11.7 - DENTON CREEK Drainage Area = 694 sq. mi.

10	ll. in: 0 ft-msl: 0	٦	2	m	7	5	9	t-	89	9
15 20 34 113 126 139 153 165 1,050				Ī	AREA IN ACT	SES				
270 340 415 490 560 635 770 780 780 2,260 2,460 2,460 2,460 2,560 2,460	10	15	0,8.	99.52	0 30 113	34	39	3 144 153	94 691	8 54 180
2,260 2,420 2,580 2,730 2,890 3,045 3,200 3,300 5,400 5,220 5,360 5,490 5,630 6,680 6,680 7,005 7,190 7,375 7,565 7,790 7,470 7,375 7,565 7,790 7,470 10,500 10,750 10,995 11,245 11,495 11,745 11,990 12,240 19,425 19,870 20,310 20,760 17,265 17,610 11,990 12,240 19,425 19,870 20,310 20,760 17,265 17,610 17,990 12,240 19,425 19,870 20,310 20,760 21,500 21,650 22,090 22,540 22,600 2,515 2,940 3,440 1,405 11,715 11,210 14,990 10,425 19,870 20,410 12,890 11,745 11,210 14,990 11,420 10,180 11,460 12,890 11,715 11,210 11,420 12,560 11,420 12,590 11,420 12,590 11,420 12,590 11,420 11,420 11,420 11,420 11,420 11,420 11,420 11,420 12,340 12,340 12,340 135,260 141,365 11,100 101,490 106,775 112,200 117,700 123,460 129,290 135,260 141,365 110,490 106,775 112,200 117,700 123,460 129,290 135,260 141,365 110,490 106,775 112,200 117,700 123,460 129,290 135,260 141,365 110,490 106,775 112,200 117,700 123,460 129,290 135,260 141,365 110,490 106,775 112,200 117,700 123,460 129,290 135,260 141,365 110,490 106,775 112,200 117,700 123,460 129,290 135,260 141,365 110,490 106,775 112,200 117,700 123,460 129,290 135,260 141,365 110,490 106,775 112,200 117,700 123,460 129,290 135,260 141,365 110,490 106,775 112,200 141,300 129,490 136,490 140,510 106,775 112,200 117,700 123,460 129,290 135,200 141,365 110,490 106,775 112,200 117,700 123,460 129,290 135,200 141,365 110,490 106,775 112,200 117,700 123,460 129,200 136,490 140,510 106,775 112,200 117,700 123,460 129,200 136,490 140,510 140,5	88	270	340	415	1,400	560 1,520	635	755	780	855 1,990
5,220 5,360 5,490 5,630 5,765 5,900 6,040 6,175 6,630 6,630 6,820 7,005 7,190 7,375 7,565 7,750 7,940 10,550 10,995 11,245 11,495 11,745 11,990 12,240 13,685 13,885 14,150 14,430 14,710 14,990 12,240 13,685 16,240 15,580 16,920 17,265 17,610 17,950 18,295 19,425 19,870 20,310 20,760 21,200 21,650 22,090 22,540 22,540 20,310 20,760 21,200 21,650 22,090 22,540 22,540 20,310 20,760 21,200 21,650 22,090 22,540 22,540 20,310 20,760 13,885 14,365 17,610 17,950 18,295 19,425 19,870 20,310 20,760 21,200 21,650 22,090 22,540 22,540 20,180 10,180 11,460 12,850 14,360 17,730 19,595 25,885 6,180 26,300 04,210 68,375 72,680 777,130 81,720 19,590 17,730 19,590 101,490 106,775 112,200 117,700 123,460 126,290 135,260 141,365 160,525 167,250 174,160 181,260 188,540 196,010 203,670 203,670 201,510 230,430 330,430 330,920 341,545 323,555 262,540 274,710 366,530 246,410 559,530 341,545 363,540 658,990 676,430 694,210 788,455 808,545 829,080 659,080 650,000 871,490 893,360 915,400 172,330 7768,810 788,455 808,545 829,080 650,000 871,490 893,360 915,675	200	2,260 3,810	2,420 3,955	2,580 4,095	2,730	2,890 4,380	3,045	3,200	3,360	3,510
9,530 9,630 1,040	985	5,220	5,360	5,490	5,630	5,765	5,900	0,040	6,175	6,310
10,500 10,750 10,995 11,245 11,495 11,745 11,990 12,240 13,020 13,300 13,585 13,865 14,150 14,430 14,710 14,990 15,895 16,240 16,580 16,920 17,265 17,610 17,950 18,295 19,425 19,870 20,310 20,760 21,200 21,650 22,090 22,540 2,560 2,560 22,090 22,540 2,560 22,090 22,540 2,560	10 H	8,500	6,820 8,695	8,890 890	9.085	9,280	9,475	9,670	9,860	10,055
15,020 15,302 15,302 15,805 16,240 16,580 16,920 17,265 17,610 17,950 18,295 19,425 19,870 20,310 20,760 21,200 21,600 22,090 22,090 22,540 22,540 22,540 22,540 22,540 22,540 22,540 23,350 23,360 23,41,545 23,5415 26,2,40 21,720 230,400 230,410 230,920 244,760 253,550 262,740 274,910 286,920 281,000 290,670 200,670 200	50	10,500	10,750	10,995	11,245	11,495	11,745	11,990	12,240	12,490
19,425 19,870 20,310 20,760 21,200 21,650 22,090 22,540 2,160 2,515 2,940 3,440 4,015 1,015 1,210 1,420 25,860 28,205 30,700 33,360 36,170 15,990 17,730 19,595 25,860 28,205 30,700 33,360 36,170 15,990 17,730 19,595 25,860 28,205 30,700 33,360 36,170 18,260 17,730 19,595 101,490 106,775 112,200 117,700 123,460 129,290 135,260 141,365 160,525 167,250 174,160 181,260 188,540 196,010 290,670 300,430 236,160 244,760 253,555 262,540 271,720 281,100 290,670 300,430 236,160 244,760 253,555 262,540 271,720 281,100 290,670 300,430 236,160 244,760 253,555 262,540 271,720 281,100 290,670 300,430 236,160 244,760 253,555 262,540 271,720 281,100 290,670 300,430 236,160 244,760 253,555 262,540 271,720 281,100 290,670 300,430 236,180 461,540 474,980 488,700 502,710 516,995 531,560 546,410 592,670 608,740 625,150 641,900 658,990 676,430 694,210 712,330 768,810 788,455 808,545 829,080 850,060 871,490 893,360 915,675	50	15,020	16,240	16,580	16,920	17,265	17,610	17,950	18,295	18,640
37 55 77 105 135 175 215 260 2,160 2,515 610 715 830 1,015 1,420 2,160 2,515 2,940 3,440 4,015 4,665 5,385 6,180 2,030 10,180 11,460 12,850 14,360 15,990 17,730 19,595 25,860 28,205 30,700 33,360 36,170 39,135 42,260 45,540 56,305 28,205 30,700 33,360 16,990 17,730 19,595 101,490 106,775 112,200 117,700 123,460 129,290 135,260 141,365 160,525 167,250 174,160 181,260 188,540 196,010 203,670 114,365 230,160 244,760 253,555 262,540 271,720 281,100 290,470 300,430 330,920 341,545 352,415 363,540 374,910 386,530 398,400 410,510	3	19,425	19,870	CAPAC	ZU, (OU	21,200 E-FEET	7,050	22,090	22,540	
37 55 77 105 135 175 215 2260 435 515 610 715 830 1,015 1,420 250 2,160 2,515 2,940 3,440 4,015 4,665 5,385 6,180 2,030 10,180 11,460 12,850 14,360 15,990 17,730 19,595 25,860 28,205 30,700 33,360 36,170 39,135 42,260 45,540 56,305 60,190 64,210 68,375 72,680 17,130 86,450 101,490 106,775 112,200 117,700 123,460 129,290 135,260 141,365 160,525 167,250 174,160 181,260 188,540 186,450 126,490 203,400 203,450 203,400 203,400 203,400 203,400 203,400 203,400 203,400 203,400 203,400 203,400 203,400 203,400 203,400 203,400 203,400 203,400										
17. 105 137 17. 105 13. 17. 2.00 1.015 1.0	1	Į.		į	0	٦,	Ч ;	# (0	16
2,160 2,515 2,940 3,440 4,015 4,665 5,385 6,180 9,030 10,180 11,460 12,850 14,360 15,990 17,730 19,595 25,860 28,205 30,700 33,360 36,170 39,135 42,260 45,540 56,305 60,190 64,210 68,375 72,680 77,130 81,720 86,450 101,490 106,775 112,200 117,700 123,460 129,290 135,260 141,365 160,525 167,250 174,160 181,260 188,540 196,010 203,670 211,510 236,160 244,760 253,555 262,540 271,720 281,100 290,670 300,430 330,920 341,545 352,415 363,540 374,910 386,530 398,400 410,515 448,375 461,540 474,980 488,700 502,710 516,995 531,560 546,410 592,670 788,455 808,545 829,080 850,060 871,490 893,360 915,675	22	3.6	رر د 15	210	105	830	1.015	1.210	1.420	1.045
9,030 10,180 11,460 12,850 14,360 15,990 17,730 19,595 25,860 28,205 30,700 33,360 36,170 39,135 42,260 45,540 101,490 106,775 112,200 117,700 123,460 129,290 135,260 141,365 160,525 167,250 174,160 181,260 188,540 196,010 203,670 211,510 236,160 244,770 253,555 262,540 271,720 281,100 290,670 300,430 330,920 341,545 352,415 363,540 374,910 386,530 398,400 410,515 448,375 461,540 474,980 488,700 502,710 516,995 531,560 546,410 592,670 608,740 625,150 641,900 658,990 676,430 694,210 712,330 768,810 788,455 808,545 829,080 850,060 871,490 893,360 915,675	8	2,160	2,515	2,940	3,440	4,015	4,665	5,385	6,180	7,050
25,860 28,205 30,700 33,360 36,170 39,135 42,260 45,540 56,305 60,190 64,210 68,375 72,680 77,130 81,720 86,450 101,490 106,775 112,200 117,700 123,460 129,290 135,260 141,365 160,525 167,250 174,160 181,260 188,540 196,010 203,670 211,510 236,160 244,770 253,555 262,540 271,720 281,100 290,670 300,430 330,920 341,545 352,415 363,540 374,910 386,530 398,400 410,515 448,375 461,540 474,980 488,700 502,710 516,995 531,560 546,410 592,670 608,740 625,150 641,900 658,990 676,430 694,210 712,330 768,810 788,455 808,545 829,080 850,060 871,490 893,360 915,675	960	9,030	10,180	11,460	12,850	14,360	15,990	17,730	19,595	21,580
56,305 60,190 04,210 68,375 72,680 77,130 81,720 86,450 101,490 106,775 112,200 117,700 123,460 129,290 135,260 141,365 160,525 167,250 174,160 181,260 188,540 196,010 203,670 211,510 236,160 244,760 253,555 262,540 271,720 281,100 290,670 300,430 330,920 341,545 352,415 363,540 374,910 386,530 398,400 410,515 448,375 461,540 474,980 488,700 502,710 516,995 531,560 546,410 592,670 608,740 625,150 641,900 658,990 676,430 694,210 712,330 768,810 788,455 808,545 829,080 850,060 871,490 893,360 915,675	275	25,860	28,205	30,700	33,360	36,170	39,135	42,260	45,540	48,970
101,490 106,775 112,200 117,700 123,460 129,290 135,260 141,365 160,525 167,250 174,160 181,260 188,540 196,010 203,670 211,510 236,160 244,760 253,555 262,540 271,720 281,100 290,670 300,430 330,920 341,545 352,415 363,540 374,910 386,530 398,400 410,515 448,375 461,540 474,980 488,700 502,710 516,995 531,560 546,410 592,670 608,740 625,150 641,900 658,990 676,430 694,210 712,330 768,810 788,455 808,545 829,080 850,060 871,490 893,360 915,675	590	56,305	60,190	04,210	68,375	72,680	77,130	81,720	86,450	91,320
236,160 244,760 253,555 262,540 271,720 281,100 293,670 211,510 236,160 244,760 253,555 262,540 271,720 281,100 290,670 300,430 330,920 341,545 352,415 363,540 374,910 386,530 398,400 410,515 448,375 461,540 474,980 488,700 502,710 516,995 531,560 546,410 592,670 608,740 625,150 641,900 658,990 676,430 694,210 712,330 768,810 788,455 808,545 829,080 850,060 871,490 893,360 915,675	335	101,490	106,775	112,200	117,700	123,460	129,290	135,260	141,365	147,010
230,100 244,700 253,757 262,740 271,720 281,100 290,070 300,430 330,920 341,545 352,415 363,540 374,910 386,530 398,400 410,515 448,375 461,540 474,980 488,700 502,710 516,995 531,560 546,410 592,670 608,740 625,150 641,900 658,990 676,430 694,210 712,330 768,810 788,455 808,545 829,080 850,060 871,490 893,360 915,675	382	160,525	167,250	174,160	181,260	188,540	196,010	203,670	211,510	219,540
350,920 341,545 352,415 363,540 374,910 380,530 398,400 410,515 448,375 461,540 474,980 488,700 502,710 516,995 531,560 546,410 592,670 608,740 625,150 641,900 658,990 676,430 694,210 712,330 768,810 788,455 808,545 829,080 850,060 871,490 893,360 915,675	2	230,100	244, 100	273,77	202,540	2/1, (20	281,100	290,070	300,430	340,390
448,372 461,540 474,950 486,700 502,710 510,995 531,500 540,410 592,670 608,740 625,150 641,900 658,990 676,430 694,210 712,330 768,810 788,455 808,545 829,080 850,060 871,490 893,360 915,675	42	330,920	341,545	352,415	303,540	374,910	380,530	398,400	410,515	452,880
592,670 608,740 625,150 641,900 658,990 676,430 694,210 712,330 768,810 788,455 808,545 829,080 850,060 871,490 893,360 915,675	3	448,375	461,540	474,980	488,700	502,710	510,995	531,500	540,410	561,540
768,810 788,455 808,545 829,080 850,000 871,490 893,300	20	592,670	608,740	625,150	641,900	658,990	676,430	694,210	712,330	730,800
	00	768,810	788,455	808,545	859,080	850,060	871,490	893,360	915,675	

TABLE 21

AREA AND CAPACITY DATA - AUBREY RESERVOIR SITE RIVER MILE 60.0 - ELM FORK TRINITY RIVER Drainage Area = 682 Sq. Mi.

6		35 109 550 2,140	7,570 10,440 10,440 14,860 20,300 26,570	48,620	2 890 190 16,970 16,970 192,730 318,800 494,180 728,120 728,120
8		32 101 510 510	6,740 10,090 10,10 19,750 25,930 32,880	00°,300 147,840	0 159 790 14,910 14,950 14,960 98,940 182,460 304,160 174,160 701,870 995,320 360,900
7		1, 800 1,	6,470 9,740 13,960 19,200 25,300	39,550 47,100	128 690 3,010 13,020 40,940 92,330 172,540 289,980 454,680 676,260 962,800 962,800
9		25 85 410 1,0630	0,00,0 6,200 9,390 13,510 18,640 24,660	38,800 46,330	102 600 2,580 11,300 37,160 85,990 162,975 276,250 435,760 651,280 930,980 930,980
5	ES	22 78 360 1,460	5,930 9,040 13,050 18,090 24,030	38,050 45,560 E-FEET	78 2,200 9,760 33,600 179,930 179,930 141,400 626,970 626,940 899,880
77	AREA IN ACRES	19 70 310 1,290	2,766 8,660 12,660 17,540 23,390	550 37,300 38,0 050 44,820 45,5 CAPACITY IN ACRE-FEET	58 1,860 8,390 30,270 74,130 144,900 250,140 339,580 603,230 869,480
0	ΨI	16 68 263 1 , 120	2,390 8,340 12,150 16,980 22,760	36,550 44,050 CAPAC	40 380 1,570 7,180 27,160 68,610 136,390 237,760 382,330 580,160 839,740 7,571,730
a		13	5,120 7,990 11,700 16,420 22,120 28,620	35,800 43,280	26 320 1,340 6,150 24,280 63,360 63,360 63,360 557,720 810,820 1132,630 1132,630
1		100 100 100 100 100 100 100 100 100 100	1,850 1,630 11,250 15,870 21,490	35,050 42,520	14 270 1,150 5,290 21,620 21,620 120,420 120,420 214,370 349,750 349,750 535,920 782,560 782,560
0		6 38 117 600	1,580 10,800 10,800 15,310 20,850	34,300 41,800 49,400	230 1,000 4,600 19,190 53,660 112,960 203,340 203,340 203,340 203,340 203,340 203,340 203,340 203,340 203,340 203,340 203,340
El. in: ft-msl:		520 530 550 550 550 550	580 590 610 620 630	640 650 660	520 530 550 550 550 550 550 550 550 550 55

TABLE 22

AREA AND CAPACITY DATA - GARZA-LITTLE ELM RESERVOIR (LEWISVILLE DAM)
RIVER MILE 30.0 - ELM FORK TRINITY RIVER
Drainage Area = 1,658 Sq. Mi.

ft-msl:	0	1	a	က	#	5	9	7	8	6
				ĄI	AREA IN ACRES	ωl				
430	η,	7.1	Co	00	00	0 %	. s	9 72	8	11
450	43	54	2%	77	38	287	112	123	135	146
160	160	310	094	620	770	920	1,080	1,230	1,380	1,530
024	1,690	2,010	2,340	2,670	2,990	3,320	3,650	3,970	4,300	4,630
780	7,960	5,310	5,650	6,020	6,380	04/29	7,100	7,460	7,820	8,310
760	8,810	9,180	9,540	9,920	10,300	10,820	11,340	11,680	12,010	12,390
200	12,770	13,360	13,950	14,440	14,940	15,500	16,410	17,060	17,700	18,390
510	19,080	19,830	20,580	27,400	22,230	22,970	23,720	54,490	25,260	26,290
520	27,310	28,320	29,370	30,120	30,910	32,220	33,090	33,900	34,840	35,730
530	36,640	37,770	38,920	040,04	41,170	42,290	43,430	74,560	45,690	146,820
540	47,910	49,310	50,710	52,110	53,510	54,910	56,310	57,710	59,110	60,510
550	61,910	63,310	017,49	66,110	67,510	68,910	70,310	77,70	73,110	74,510
3	27/1/1									
				CAPACITY	ITY IN ACRE-FEET	-FEET				
430							7	9	13	22
011	35	50	69	8	113	140	170	200	540	280
450	320	370	430	200	580	989	82	8	1,030	1,170
1460	1,320	1,550	1,940	5,480	3,170	4,020	5,020	6,170	024,7	8,930
024	10,540	12,390	14,560	17,060	19,890	23,050	26,530	30,340	34,480	38,940
1480	43,740	48,870	54,350	60,190	66,390	72,940	79,860	87,130	94,770	102,840
064	111,400	120,390	129,750	139,480	149,590	160,160	171,240	182,750	194,290	206,830
200	219,330	232,430	546,080	260,290	274,940	290,240	306,090	322,790	340,150	358,250
510	377,000	396,430	416,590	437,560	459,460	482,970	505,300	529,460	554,330	580,120
520	606,930	634,710	663,500	693,300	723,80	755,330	787,970	821,520	855,880	891,150
530	927,330	964,540	1,002,870	1,042,340	1,082,940	1,124,680	1,167,540	1,211,530	1,256,660	1,302,920
540	1,350,200	1,398,800	1,448,800	1,500,200	1,553,000	1,607,200	1,662,800	1,719,800	1,178,200	1,838,100
550	1,899,300	1,962,000	2,026,000	2,091,400	2,152,800	2,226,400	2,296,000	2,367,000	5,439,400	2,513,200
	(

Area-capacity based on resurvey of Lake Dallas in 1952.

TABLE 23

AREA AND CAPACITY DATA - LAVON RESERVOIR RIVER MILE 55.9 - EAST FORM TRINITY RIVER Drainage Area = 777 Sq. Mi.

6		12,690 5,170 9,630 14,530 19,550 26,250 33,470 42,920		30,000 39,000 112,530 233,210 403,580 631,760 930,210 1,311,030
ω		1,390 4,820 9,180 14,040 19,050 25,560 32,740		20 3,370 34,010 103,130 218,920 384,280 605,850 897,100 1,268,600
7		6 1,060 4,460 8,720 13,550 18,550 24,880 32,020		2,140 29,370 94,180 205,130 365,490 580,630 864,720 1,227,130
9		720 4,110 8,260 13,050 18,040 24,190 31,290 40,010		8 1,250 25,080 85,690 191,830 347,190 556,100 833,060
5	क्ष	3,760 3,760 7,810 12,560 17,540 23,500 39,940	ACRE-FEET	660 21,140 77,650 179,020 329,400 532,260 802,130 1,147,120
#	AREA IN ACRES	220 3,410 7,350 12,070 17,040 22,810 29,840 38,070	CAPACITY IN ACRE	17,560 17,560 70,080 166,710 312,110 509,110 771,930
ю	Ŧ	90 3,050 6,890 11,570 16,540 22,120 29,120 37,100	CAPAC	0 14,330 62,960 154,890 295,330 486,640 742,450
2		2,700 6,430 11,080 16,030 28,330 36,130		96 11,450 56,290 143,560 279,040 464,870 713,690 1,034,360
1		26 2,350 5,980 10,590 15,530 20,740 27,670 35,160		66 8,930 50,090 132,730 263,260 443,780 685,670
0		2,000 5,520 10,090 15,030 20,050 26,940 34,190		6,760 1022,400 247,990 423,390 658,360 964,040 1,354,430
El. in: ft-msl:		II	-80	130 1410 1410 1410 1410 1410 1410 1410 1

TABLE 24

AREA AND CAPACITY DATA - BARDWELL RESERVOIR RIVER MILE (.O - WAXAHACHIE CREEK Drainage / rea = 171 Sq. Mi.

6	60 67 647 718 1,600 1,700 2,660 2,770 3,780 3,890 5,250 5,400 6,910 7,080 9,050 9,270	244 308 270 3,950 260 15,910 510 38,220 670 71,500 500 117,800 500 117,800 600 261,700 600 261,700
7 8	52 1,500 2,550 3,670 5,090 6,740 6,740 6,140 11,440	2,660 3,270 12,720 32,900 35,510 63,940 67,670 107,300 112,500 166,300 243,600 243,600 355,900
9	1,400 2,440 2,440 3,550 4,940 6,570 8,600	2,120 11,270 11,270 30,400 60,330 60,330 102,300 159,700 159,700 159,700 333,000 34,900 333,000
5	ACRES 37 432 60 2,340 6,410 6,410 6,410 6,410 6,410 6,410 6,410 6,410 6,410 6,410 6,890	250 250 250 250 250 250 250 250 250 250
4	15, 63, 15, 15, 15, 15, 15, 15, 15, 15, 15, 15	25,73 8,68 8,68 52,73 52,73 52,74 52,92 218,92 311,33
8	23 289 1,090 2,120 3,210 4,470 6,070 7,930 10,330	23, 50, 140, 210, 300,
a	218 298 3,100 3,100 4,310 7,700	18 674 674,00 21,480 47,020 83,770 134,700 202,300
1	1,910 1,910 1,910 1,160 1,160 1,180 1,170	6 492 5,550 19,520 43,980 79,530 128,900 194,700 280,700
n: 0 ::1	1,790 1,800 1,800 2,870 4,000 5,560 7,250 9,500	381 4,710 17,660 11,660 41,050 75,450 123,300 187,300 271,100
El. in ft-msl	338 420 420 420 420 420 420 420 420 420 420	2388 2388 2498 2498 2498 2498 2498 2498 2498 24

AREA AND CAPACITY DATA - NAVARRO MILLS RESERVOIR RIVER MILE 63.9 - RICHLAND CREEK Drainage Area = 316 Sq. Mi.

6		1.5 36 1,690 3,900 6,510 9,650 14,600	2.8 166 11,000 11,000 38,400 89,000 169,700 291,500
8		1,1 388 1,460 3,610 6,120 14,160 18,900	1,450 9,470 34,600 82,700 160,300 142,000
7		0.7 28 310 1,250 3,350 5,730 8,980 13,730 18,420	0.6 1,110 8,120 31,100 76,800 151,100 263,200 423,300
9		0.3 24 230 1,070 3,100 5,420 8,670 13,250	0.1 76 838 6,960 27,900 71,200 142,300 249,700
5	ωl	20 170 910 2,900 5,170 8,360 12,750 17,450	ACRE-FEET 0 5,4 10 5,970 0 24,900 0 65,900 0 133,800 0 236,700 0 387,500
4	AREA IN ACRES	16 124 830 2,690 4,970 12,230 16,960 22,120	15,100,100,100,100,100,100,100,100,100,1
3	AR	2,500 4,700 11,700 11,100 21,510	22 384 4,300 19,500 55,900 6,55,900 6,55,900 117,600 112,600 212,200 2
5		65 680 2,310 4,600 7,470 11,150 16,000	3,580 3,580 17,100 51,300 110,000 200,800 337,300 521,700
1		610 610 2,130 4,420 7,170 10,600 15,510 20,440	2,940 2,940 14,900 46,700 102,700 189,900 321,600
0		2 40 530 1,950 4,200 6,870 10,080 15,000	2,370 2,370 12,900 42,400 95,700 179,600 306,300
El. in: ft-msl:		330 200 200 200 200 200 200 200 200 200	330 330 450 450 450 450

II-82

TABLE 26

AREA AND CAPACITY DATA - TENNESSEE COLONY RESERVOIR SITE RIVER MILE 339.2 - TRINITY RIVER Drainage Area = 12,687 Sq. Mi.

			134 19,950 19,950 39,950 65,190 130,680 130,680	866 866 866 866 866 866 866 866 866 866
	6		1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	200 1,130 2,900 17,900 134,100 429,200 950,100 1,719,000 2,693,000 3,866,300 5,293,300
	8		46 125 3,650 18,030 37,750 62,610 85,950 127,800 127,800	1,000 2,680 13,800 115,100 0 390,300 1,631,900 1,7 0 2,587,700 2,6 0 3,737,100 3,8 0 5,139,700 5,2
			4.000444	1 0 0 0 0
	7		39 204 2,800 16,200 35,690 59,950 83,750 102,700	110 88 2,470 10,600 98,000 353,600 824,900 1,547,000 2,482,400 3,610,800 4,988,500
	9		31,090 14,550 14,550 33,500 57,350 100,900 121,900	75 2,270 8,190 82,700 319,000 1,464,400 2,382,400 3,487,500
			25 100 1,100 12,830 31,400 54,330 79,250 99,330 119,500	388888888888888888888888888888888888888
	5	ωl	12 33 34 54 79 119 119 1145	50 660 69,080 69,080 710,400 710,400 710,400 710,400 710,400 71,384,000 2,282,300 4,693,300
	4	N ACRES	18 92 176 990 11,350 29,330 51,690 76,990 77,350 97,350 116,800 1142,500 1142,500	25 1,900 5,190 56,900 256,200 657,400 1,305,900 2,183,900 3,248,600 4,549,600
		AREA IN	IIIX	
)	3		10 84 168 710 9,900 27,330 49,190 74,750 95,700 114,400	10 475 1,730 46,300 227,900 607,000 1,230,000 2,087,400 3,133,000 4,408,300
	2		6 160 160 140 8,350 25,330 46,730 72,330 93,850 112,000	395 1,570 3,760 37,100 201,500 201,500 559,000 1,156,500 1,992,600 3,019,800 4,269,400
			68 150 300 6,960 23,330 14,330 70,000 92,150 109,800	320 320 320 320 320 320 320 320 320 320
	ı		1982, 44, 44, 44, 44, 44, 44, 44, 44, 44, 4	320 1,410 3,330 25,500 177,200 513,500 1,085,300 1,899,600 2,908,900 4,132,700
	0		60 140 230 230 230 230 67,610 67,610 90,390 103,800 153,200	260 3,120 3,120 23,100 1154,800 470,200 470,200 998,400 998,200
			71,000 EN	\$ 30 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
	1. in: t-msl:		1,90 1,90 1,90 1,90 1,90 1,90 1,90 1,90	190 200 200 200 200 200 200 200 200 200 2
	ाच भा		II - 83	

- 87. DETERMINATION OF RESERVOIR INFLOWS. Monthly flows were estimated at existing and investigated reservoir sites in the Trinity River Basin for the period 1924 through 1957. Preliminary estimates of flows were generally based on observed flows at gaging stations in the basin. Inflows to the existing reservoirs, during their period of operation, were computed from the observed change in storage, releases, and evaporation at the reservoirs. However, since the flow estimates described above reflect the varying degree of basin development that was taking place throughout the 1924-1957 period, it was necessary to adjust these estimates in order to reduce all flows throughout the period to the basis of existing (1958) conditions of basin development. The estimated monthly and annual flows at Benbrook, Grapevine, Garza-Little Elm, Lavon, Bardwell, and Navarro Mills Reservoirs and at Lakeview, Roanoke, Aubrey, and Tennessee Colony Damsites under existing (1958) conditions of basin development are given in tables 27 through 36.
- 88. The monthly flows for the period 1924-1940 were adjusted to 2020 conditions of basin development in the same manner as the flows under existing conditions of basin development. However, monthly flows under 2010 conditions of basin development had previously been determined for the 1941-1957 period by the United States Bureau of Reclamation for the United States Study Commission - Texas. In view of the uncertainty as to the actual degree of basin development that will be accomplished by the year 2020, it was concluded, after an analysis of the data, that the flows for the 1941-1957 period, as published by the United States Study Commission - Texas for 2010 conditions would generally also be applicable to 2020 conditions of basin development and were so adopted in this report. The one exception was at Lakeview Reservoir where records maintained by the Dallas Power and Light Company at the existing Mountain Creek Dam were used, and applicable adjustments were made to estimate flows under 2020 conditions of basin development for the 1941-1957 period.

TABLE 27 SETIMATED NORTHLY AND ANNUAL FLORE IN AGRE-FREE AT BENEROOK ROSSERVOIR - EXISTING (1998) CONDITIONS

TOTAL	21.400	7,000	009	5.900	14,200	20,400	10.500	10,200	49,200	18,800	2,300	34,700	14.400	9,700	45,100	2,600	19,000	127,700	188,300	39,100	45,000	183,900	77,300	44,700	54,700	158,500	112,900	17,600	000.6	2,800	006	4.200	11 300	224,700	1,594,600	
DECEMBER	0	0	100	0	1.900	0	1.000	0	1,500	0	0	200	1,800	1,500	0	0	12,400	1,500	3,100	200	2,000	700	17,700	700	0	1,100	1,100	100	0	0	0	0	900	3,100	96,800	
NOVEMBER	0	100	0	0	0	0	500	0	200	0	0	200	006	500	0	0	2,400	800	3,700	0	2007	800	20,800	700	0	8	86	0	200	100	0	0	100	5,800	39,400	
OCTOBER	0	500	300	2005	0	0	000	0	500	0	0	200	2,300	300	0	0	0	2,300	17,500	0	1,300	1,300	1,200	200	0	8,500	1,500	0	0	909	0	500	1.400	2,900	14,400	
SEPTEMBER	0	0	1.800	0	0	0	0	0	7,800	200	0	300	2,600	0	0	0	0	200	1,600	1,800	009	200	200	200	0	009	15,500	0	0	0	0	200	0	1,700	38,600	
AUGUST	200	0	1.400	0	100	0	0	0	0	004	0	0	0	0	0	0	200	3,700	1,000	0	800	300	2,000	100	0	009	7,600	0	0	0	0	0	500	800	16,400	
JULY	100	0	100	0	100	0	0	200	3,100	800	0	200	0	0	300	200	1,900	2,800	1,200	1,900	300	3,500	200	004	1,700	1,900	6,800	1,300	0	0	100	200	200	5,600	32,400	
JUNE	1,300	0	300	200	1,200	1,200	500	300	2,300	009	0	5,300	0	1,300	1,00	300	1,000	28,900	15,100	5,700	2,200	3,400	7,000	9,600	1,400	18,100	3,900	9,700	200	0	0	1,600	200	34,000	150,900	
MAY	5,500	5,200	1,900	100	904	5,500	8,100	700	2,100	7,000	8,	26,400	1,300	200	2,500	1,100	1,000	17,400	41,900	14,100	22,900	9,200	11,300	3,300	3,600	101,500	26,500	1,900	4,900	1,500	200	1,500	6,800	122,500	457,500	
APRIL	4,300	1,000	2,200	1,000	8,300	3,200	0	2,100	800	1,600	200	38	0	909	6,300	1,000	100	11,600	100,600	5,700	3,200	900,64	2,800	8,300	5,600	9,000	21,100	82	2,500	904	804	100	906	49,300	298,700	
MARCH	9,300	100	909	1,000	9009	3,900	100	3,900	3,400	6,600	800	300	100	3,400	10,400	0	0	12,700	800	6,500	004,4	62,400	9,000	8,300	13,300	13,500	4,900	1,00	100	200	100	100	0	009	179,700	
FEBRUARY	300	100	0	100	1,500	5,400	0	2,700	15,300	2,200	200	200	200	904	15,000	0	0	38,000	200	1,200	6,200	48,600	8,300	3,600	26,400	2,40	20,600	2,000	289	0	0	0	800	1,200	207,100	
JANUARY	004	0	909	0	100	1,200	0	300	15,500	2,400	180	989	200	1,800	10,200	0	0	7,800	1,100	2,000	8	4,500	2,500	7,800	2,78	100	2,500	88	200	0	200	0	100	200	72,700	
YEAR	1924	25	56	27	28	53	1930	Ħ	SA,	33	34	35	36	37	38	36	1940	147	7.	43	7	4	9.	2.7	9.	64	1950	7	X	53	式	52	8	1957	Total	

TABLE 28 SETIMATED MONTHLY AND ANNUAL FLOME IN ACRE-FEET AT LAKENTEN DANSITE - EXCEPTING (1998) CONDITIONS

TOTAL		29,100	22,100	28,300	33,300	69.100	56,300	2008	000 70	100 700	100,100	30 700	50,100	20,200	27,500	82.500	000,000	108,700	81.20v	160,000	10,500	55 600 55 600	67,100	68 900	27 700	7 300	02 100	98 300	18 000	32 700	22,600	31,900	38	14,700	12,900	156,000	1,880,800	KF 300
DECEMBER		0	0	0	100	32,500	200	4,800	100	0 200	1 400	8	001.0	1 200	20 700	300,100	300	16 900	1 300	000	700	200		2 000	000 76	0	0000	0	0	2 8m	889	905	400	200	1,100	4,300	135,800	3 000
NOVEMBER	-	0 000	4,200	0	0	0	200	0	0	0	300		1.200	2.000	0.00			12.300	0	209	C	1.900	300	11.800	100	006	0	0	700	2000	0000	300	000	000	30,600	T3,000	65,000	1.910
OCTOBER		000	1,100	0	10,200	0	1,200	2,300	500	0	0	0	009	0	4.200	200	0	1,100	700	10,800	0	0	500	0	0	700	8,100	0	0	0	700	100		0 0	2002	2	42,200	1.240
SIZTIMBER	80.5	202	3	0	200	0	1,200	100	0	8,300	0	0	400	22,100	700	0	004	800	0	2,500	300	500	200	0	1,400	0	0	2,300	700	009	300	100	0) 0	0		43,300	1,270
AUGUST	82	3	00	0	0	0	0	0	100	0	0	0	0	0	0	100	100	500	4,600	0	500	1,600	200	0	11,300	200	300	1400	200	100	0	100	1.500	909	100		22,600	099
JULY	906	80	2 600	2,000	0 000	2,000	0	0	200	3,800	11,800	0	700	0	200	2,500	0	26,300	2,000	1,500	1,000	200	200	0	0	0	0	4,100	100	1,200	1,200	1,300	0	800	1.200		69,900	2,060
JUNE	1 300	0	3 000	386	20,000	17, KOS	1,700	1,700	1,100	900	1,100	0	26,400	0	2,400	1,200	8,200	30,100	35,700	21,200	7,000	1,200	800	2,900	0	88	880	2,300	14,000	0	0	0	2,800	1,200	2,400		195,600	5,760
MAY	4.800	15,600	000	7 500	2,1	000	10,900	22,66	2,200	15,600	22,500	300	24,900	3,700	7400	1,300	4,300	12,700	11,200	39,800	2,200	38,400	1,500	31,900	0	1,500	38,300	24,100	300	8,400	27,100	2,300	7,300	7,600	50,000		483,800	14,230
APRIL	5,600	200	11.900	7 000	000	200,00	27,000	3,300	2,400	6,400	4,300	14,900	004	0	1,200	8,300	2,800	4,000	3,900	80,300	2,100	2,300	11,100	0	0	1,500	200	12,900	1,200	4,100	4,800	804	200	0	80,900	,	306,500	9,020
MARCH	14,500	0	200	7.100	1 500	2007	200,00	2000,7	12,200	009,1	13,500	9,600	300	0	1,400	21,200	3,500	100	200	1,200	2,700	4,600	20,500	98	0	000	200	2,000	0	200	2,300	100	100	200	1,900	10.	184,300	5,420
FEBRUARY	1,300	0	100	0	3.800	1, 600	286	250	2,300	24,300	004,7	3,38	1,800	0 0	0	0 000	2,500	1,200	20,500	82	0	4,700	00101	12,400	0 000	2,300	13,300	45,900	1,100	300	300	006	200	1,100	500	200	190,600	5,610
JANUARY	1,200	0	6,300	0	100	9	300,0	884	20 400	33,000	12,100	2,000	1,200	11 800	20,11	46,400	00	0 000	3,500	82,0	0 0	0 00.	2,200	3,400	00	28	2,700	3,100	8.5	891	400	0	200	38	188	41.4 000	141,200	4,150
YEAR	1961	25	56	27	28	00	10201	2730	7.5	X	23	4	25	25	700	200	5000	1240	T#:	Y C	5+3	1 1	7	2 5	+ -	9 5	1000	RAT	7 6	X	22	*	55	8	1957		Total	Mean

TABLE 29
SETIMATED MONTHLY AND ANNUAL FLORS IN AGRE-FEED AT ROANOKE DAMSITE EXISTING (1958) CONDITIONS

TOTAL	73,600	26,300	76,900	107,000	136,600	159,300	63,000	41,200	242,200	105,700	000,49	218,100	41,700	86,500	233,600	17,300	132,100	272,500	369,500	86,700	111,700	251,000	177,800	59,200	72,500	98,500	192,100	31,800	16,500	32,300	16,700	17,400	15,900	452,400	4,064,600	119,550
DECEMBER	0	0	7,100	5,500	29,800	200	6,400	1,100	19,500	700	0	16,700	8,300	16,400	0	0	39,000	8,500	2,400	004	2,600	1,800	28,800	12,100	0	009	1,200	0	500	1,000	009	0	1.200	3,400	218,800	6,440
NOVEMBER	500	500	500	0	1,400	200	200	0	200	1,000	700	11,100	4,700	2,700	0	0	20,600	10,100	2,000	0	2,800	1,800	22,000	200	0	909	80	0	009	2,400	100	200	909	20,000	111,100	3,270
OCTOBER	0	2,200	1,500	2,900	0	500	500	200	8	500	0	3,500	12,800	1,500	0	0	0	32,900	7,700	500	8	16,300	0	0	0	18,000	1,800	0	0	7,56	009	500	009	3,000	116,200	3,420
SEPTEMBER	0	0	2,000	8	0	0	0	0	2,800	1,000	0	2,300	006,4	82	0	0	0	9	4,400	0	1,400	3,800	1,600	0	0	2,000	28,800	200	0	004	009	1,000	0	1,800	909,09	1,780
AUGUST	888	200	5,400	1,000	300	0	0	500	6,300	1,000	0	0	0	004,4	0	0	5,800	3,800	1,400	0	88	904	904	0	0	0	7,600	0	0	500	004	200	904	0	37,400	1,100
NULY	500	0	11,100	2,700	004,4	1,000	82	0	25,900	500	0	1,600	0	0	200	38	37,100	3,400	2,000	004	004	14,700	1,000	0	2,200	7,900	43,000	6,100	0	800	500	0	904	1,200	168,900	016,4
JUNE	12,700	200	14,800	1,000	11,400	12,400	1,100	009'9	3,000	5,500	1,100	89,500	8	8	7,800	300	17,400	120,000	47,200	10,100	3,400	000,9	28,200	1,800	1,600	17,700	14,300	17,500	2,400	200	3,400	6,300	200	28,400	518,300	15,240
MAY	7,000	16,500	10,300	3,900	11,200	75,000	47,100	2,900	8,400	23,800	11,800	72,600	2,700	5,000	3,000	1,700	000,6	12,900	60,300	33,500	36,500	6,000	28,600	14,500	3,000	42,200	61,100	2,200	2,800	10,700	4,800	7,300	7,700	196,200	845,200	24,860
APRIL	12,400	9,600	10,400	009,94	53,400	11,800	7,800	7,400	2,400	8,900	18,200	8,700	8%	7,100	35,100	11,100	3,000	33,900	226,900	6,900	17,900	00 1 , ₩	5,200	15,300	2,400	1,000	11,900	1,200	7,300	8,500	2,000	904	1,000	140,800	775,400	22,810
MARCH	35,300	500	о»,п	56,600	006,4	15,500	8	14,300	8,200	32,500	20,500	3,000	1,500	14,400	46,100	2,900	88	21,10	2,000	27,800	13,900	1,000	12,700	7,300	10,100	7,100	2,400	1,800	500	89	88	1,000	904	1,800	418,800	12,320
FEBRUARY	2,200	200	0	10,500	16,200	18,300	1,500	4,500	55,500	2,000	9,900	2,800	2,300	5,100	84,400	1,000	0	28,000	3,200	1,800	27,200	72,800	31,100	2,400	40,100	1,400	17,000	1,800	0	0	88	909	3,200	1,400	451,200	13,270
JANUARY	3,400	0	3,100	5,800	3,600	23,900	38	8	109,100	23,900	4,800	6,300	3,100	31,500	57,000	0	0	7,300	7,000	1,600	1,000	6,000	18,200	2,600	12,100	0	5,200	1,88	0	0	2,600	200	200	904	341,700	10,050
YEAR	1924	25	98	27	28	53	1930	H	, SX	33	34	35	36	37	38	39	1950	147	4	43	ŧ	45	3	14	84	64	1950	K	R	53	た	55	R	1957	Total	Mean

TABLE 30 ESTIDACTED MONTHLY AND ANNUAL FLOIS IN ACRE-FEET AT GRAFEVING RESERVOIR - EXISTING (1998) CONDITIONS

TOTAL	Pdl. Kon	04,000	88 100	123 200	156.900	184 100	70,100	47 400	278 200	121,600	73.600	250,600	47.900	007,00	268,400	20,100	152,000	313,100	454,600	94,800	128,400	288,000	204.700	67,800	82,200	113,200	221,100	36,500	18,800	37,100	19,200	20,200	17.900	485,100	4,670,500	137.370
DECEMBER	C	00	8 200	6,300	34,200	909	7.300	1,300	oo Too	800	0	19,200	0.500	18,800	0	0	44,800	9.700	2,800	7000	6.300	5,000	33,100	13,900	0	009	1,400	0	200	1,200	009	0	1.400	3,800	250,800	7,380
NOVEMBER	2000	200	2002	0	1.600	800	200	0	0000	1.200	800	12,800	5,400	3,100		0	23,700	11,700	5,800	0	3,200	5,000	25,400	200	0	800	1,000	0	009	2,800	200	200	009	23,000	127,900	3,760
OCTOBER	0	002	1,700	3,300	0	500	200	800	000	500	0	4,000	14,700	1.700	0	0	0	37,900	8,900	500	1,000	18,600	0	0	0	20,800	2,000	0	0	8,700	900	500	009	3,400	133,200	3,920
SEPTEMBER	0	0 0	2.300	009	0	0	0	0	3.200	1,200	0	2,600	5,600	009	0	0	0	909	5,000	0	1,600	4,400	1,800	0	0	2,200	33,100	200	0	904	800	1,200	0	2,000	69,400	2,040
AUGUST	500	500	6,200	1,200	700	0	0	200	7,200	1,200	0	0	0	5,000	0	0	6,700	4,200	1,600	0	1,000	004	700	0	0	0	5,400	0	0	200	700	200	700	0	42,700	1,260
JULY	500	0	12,800	3,100	2,000	1,200	9	0	29.800	200	0	1,800	0	0	200	700	42,700	4,000	2,200	700	7,00	16,900	1,200	0	2,600	9,100	004,64	7,100	0	1,000	200	0	100	1,400	194,300	5,710
JULE	14,600	200	17,000	1,200	13,100	14,200	1,300	7,600	3,400	6,300	1,300	102,900	1,000	1,000	000,6	004	20,000	137,900	54,300	11,700	7,000	6,700	32,300	2,000	1,800	20,200	16,500	20,000	2,800	200	4,000	7,300	200	60,100	296,500	17,540
MAY	8,100	19,000	11,800	4,500	12,900	86,200	54,100	6,800	009,6	27,400	13,600	83,500	3,100	2,300	3,400	2,000	10,400	14,900	69,200	38,500	41,900	006,9	32,900	16,700	3,400	48,600	70,200	2,600	6,500	12,300	2,600	8,500	8,900	225,500	971,800	28,580
APRIL	14,300	7,600	12,000	53,600	61,400	13,600	5,500	8,500	2,800	10,200	20,900	10,000	009	8,200	40,380	12,800	3,500	38,900	260,800	2,900	20,600	51,200	9,000	17,600	2,800	1,200	13,700	1,400	3,500	9,700	2,200	907	1,200	161,900	891,800	26,230
MARCH	10,600	200	12,600	30,600	2,600	17,800	1,000	16,400	9,400	37,300	23,600	3,400	1,700	16,600	53,000	3,300	200	12,700	5,800	31,900	16,100	88,500	14,700	8,300	11,700	8,100	2,300	2,000	200	989	899	1,200	90#	5,000	1480,900	14,140
FEBRUARY	2,500	200	0	12,100	18,600	21,000	1,700	5,200	63,800	3,100	1,900	3,200	2, 700	5,900	97,000	1,200	0	32,100	3,600	2,000	31,18	63, 700	35,900	2,800	600,00	1,900	009,61	2,000	0 0	0	1,000	888	3,680	1,600	518,500	15,250
JANUARY	3,900	0	3,600	6,700	4,100	27,500	904	009	125,400	27,500	2,700	7,200	3,000	36,200	50,500	0	0 00	3,700	4,600	1,000	1,200	6, 700	21,000	20,300	13,900	9	000,0	1,400	0 0	0 000	3,000	202	500	400	392,700	11,550
YEAR	1924	52	50	27	23	520	1930	A	S.	25.5	4	32	200	200	0, 6	2010	1750	7 07	y c	72	1.5	7	9 1	100	9 9	1050	200	18	X C	25	* !	27	81	1951	Total	Mean

TABLE 31 ESTINATED MONTHLY AND ANNUAL FLORG IN ACRE-FEET AT AUGREY DANSITYS - EXISTING (1958) CONDITIONS

JANUARY	FEBRUARY	MARCH	APRIL	MAY	SUMB	YILL	AUGUST	SEPTEMBER	OCTOBILE	NOVEMBER	DECEMBER	TOTAL
4 600	3 200	53 300	20 Rm	001 01	1 200	009	000	8	85		1	200
200	200	200	20,51	1001	300	3	32	36	200	8	3 8	36,76
8	100	2000	2005 01	200	17 800	ouc or	2 2 2	20,1	836	28	201 15	26,00
36	200	300	17,000	300	300	20,44	77,00	7,00	2000	20,1	74,400	100,100
24,40	29,000	23,000	30,4	20,000	0,100	201,51	3	3	10,200	3,100	2,30	250,900
3,500	3,300	3	3,000	10,200	13,800	3,500	8	200	1,700	1,900	8,000	26,30
7,100	2,700	2,300	6,200	73,600	17,300	8	20	3,600	7,100	1,400	14,100	143,000
1,300	1,600	1,200	1,400	45,400	3,000	1,100	1,100	9	8,000	8,200	24,100	97.000
5,800	13,700	31,500	12,900	3,200	3,600	2,500	2,000	1,400	5,700	1,700	3.300	87.300
96,300	85,500	26,900	7,100	12,700	2,000	25,200	5,600	5,100	2,700	3,300	10,700	283,100
8.800	000.9	36,000	5.500	36,300	12,000	6.700	8.000	6 100	2,000	200	1,600	125,00
3,400	3.400	11,200	12,300	8,600	1,600	1,600	1,400	300	300	200.00	1,300	ho 70
2 100	2500	2010	2000	170,000	9000	800	2019	200	200	86,19	22,000	2000
3	2,300	36.0	200	200	20,00	3000	20,0	36,50	3,000	0,10	35,900	30,30
3	3,50	3,10	7,000	2,70	2,400	2,000	7,700	24,000	34,900	18,000	2,000	115,20
22,100	6,40¢	8,300	3,700	3,100	2,800	5,000	17,700	8,000	2,100	2,600	7,500	83,30
21,200	74,300	80,800	45,800	4,300	3,900	2,400	6,300	2,300	1,600	06	002	244.50
200	800	3,200	15,900	5.800	5.000	5.900	3,000	2,400	2,100	3.700	1.400	41.80
1.400	1.400	1.900	13.600	15,500	28,100	24,300	300	3,200	3.200	17.200	200	168 80
16,200	12,300	22,100	41,800	26.400	169,500	8,600	007.7	7,400	14.200	16.600	2,200	341 70
4.700	3,300	2,900	272,000	60,100	1,2,200	7,000	6.800	8,600	10,600	3.900	000	108.10
4.300	6,300	25,800	13,500	25,800	19,800	001.4	4,100	4,200	2,900	1,800	5,000	114.90
2,400	12,000	26,100	14.900	\$6.200	12,100	6,200	009.9	6,100	7,600	4.400	10.900	162.50
5,800	88,200	156,200	90,700	9,300	34,200	36,500	5,700	009.6	36,100	7,700	5.700	185,70
13,500	27,600	23,700	15,700	14,800	106,800	9,000	6,200	6,300	5,500	50.200	90,500	390.80
12,500	2,900	10,900	10,800	9,300	18,500	8,100	000.6	7,300	2,000	004.4	19.500	120,00
12,200	47,600	39,100	3,500	20,300	10,600	12,500	9.800	9,100	5.500	3,000	5.500	175.70
7,500	15,600	10,300	4,200	38,300	23,700	000,4	3,200	3,900	19,600	10,500	5,300	143.10
29,500	57,700	009'6	5,700	80,400	25,700	11,300	25,300	89,700	9.700	700	3,300	340.60
1,800	2,700	2,000	2,200	3,000	23,600	10,500	7.100	000.9	7,800	2,400	2,700	68.80
2,000	1,700	2,200	10,700	5,400	3,400	4,100	5,500	4.200	100	1,800	1,500	109.600
202	202	2,600	29,100	26,400	0	006	100	100	4.100	2,500	2.400	200
4.700	1.500	9	1.500	16,400	7.000	3.000	0	2005	4.800	200	1,600	10,30
1,100	9,400	3.000	3.400	25,100	15,900	500	0	5.300	500	100	300	28.00
1,700	5.200	1.000	200	8.400	1.200	300	2 700	1,600	300	2 800	700	36,36
2 100	200	11 200	ONE CALC	2015 100	68,100	25,300	20,00	1,500	200	82,300	36.	20,00
2,400	20260	20017	c*c, 3%	OT'(C+2	20,100	62,300	50,300	1,300	2,300	03,300	0,300	(5),10
335,400	000,695	673,900	1,002,500	1,164,400	769,000	292,700	180,300	242,900	234,600	280,800	343,500	6,086,00
9.780	16.740	19.820	29.400	34.250	000.00	8.610	2 300	041.7	000 9	8 260	001.01	200 07.1
9,180	16,740	19,620	29,490	34,250	22,020	9,610	2,300	7,140	006,9	à	500	260 10,100

TABLE 32

ESTINATED MONTHLY AND ANNUAL FLOWS IN ACRE-PRET AT GARZA-LITTLE ELM RESERVOIR (LEWISVILLE DAM) EXERTING (1958) CONDITIONS

TOTAL	000 986	89,700	411,500	538,600	137,100	348,400	237,000	213,200	690,300	304,800	121,000	751,900	280,700	203,400	596,100	101,900	411,600	833,000	1,043,800	280,100	336,500	1,184,900	925,900	295,500	428,300	346,200	82,600	167,600	104,000	177,700	103,100	141,000	88,500	1,768,800	14,841,600	065.964
DECEMBER	1.700	500	35,200	55,800	19,400	34,400	58,800	8,100	26,100	3,900	3,100	82,600	12,100	18,200	1,900	3,300	133,400	12,600	14,600	006,4	56,600	14,000	147,500	006,94	6,100	2,600	8,100	6,500	3,700	2,900	3,900	202	11,500	50,300	837,600	24.640
NOVEMBER	c	2.100	5,500	7.500	7,600	3,300	20,100	4,200	8,100	6,500	2,600	19,800	73,900	6,400	2,100	000,6	41,900	40,500	8,400	001,4	10,800	18,800	122,400	10,800	7,400	25,700	11,500	2,800	001,4	13,400	1,700	500	6,800	203,200	684,800	20.140
OCTOBER	006	12.600	14,100	24,800	4,200	17,200	19,600	14,000	6,600	12,300	3,100	12,200	85,200	5,100	3,900	5,200	7,700	34,600	25,900	7,100	11,200	88,000	13,400	12,300	13,300	44,900	23,600	209,11	300	06,6	11,600	004	2,600	2,000	571,700	16.810
SEPTEMBER	200	0.800	3,900	1,200	009	8,800	1,500	3,400	12,400	15,600	3,100	13,800	60,500	19,600	2,600	5,800	7,700	10,700	21,000	10,200	14,800	23,400	15,300	17,800	22,100	9,500	218,700	14,600	10,200	1,000	1,200	5,500	4,000	18,400	991,900	17.410
AUGUST	009	1.700	36,600	1,000	1,900	1,700	2,700	4,800	004.9	19,600	3,300	15,600	4,200	28,600	15,400	7,300	10,600	10,700	16,500	10,000	16,200	14,000	15,100	21,900	23,900	2,900	25,100	17,200	13,400	500	0	0	6,500	20,100	000,044	12.040
JULY	1.500	0	120,100	29,400	8,500	2,100	2,800	6,200	61,400	16,400	3,900	14,200	4,800	006,4	5,800	7,100	59,300	27,000	17,100	10,700	15,200	89,100	14,600	19,800	30,500	9,700	27,600	25,700	10,100	2,300	7,400	909	3,100	61,800	714,700	21.000
JUNE	3.00	100	43,300	19,800	33,700	42,100	7,300	8,800	12,200	29,200	3,900	146,400	5,800	14,200	9,400	7,100	68,500	413,300	102,900	48,300	59,600	83,300	260,600	45,200	25,900	57,700	62,600	57,500	8,300	0	17,100	38,700	2,900	166,100	1,875,1∞	55.150
MAY	25,300	20,500	78,700	50,800	24,900	179,400	110,800	7,700	30,900	64,200	27,000	416,800	28,100	7,500	10,600	6,900	37,700	001,49	146,700	62,900	137,000	22,800	109,200	22,700	004,64	93,500	196,200	1,400	13,100	64,500	39,900	61,200	20,500	294,900	2,840,100	83.820
APRIL	55.600	30.000	47,500	109,300	20,900	15,200	3,400	31,100	17,200	13,300	30,000	2,900	3,800	000,6	111,600	38,700	33,100	106,000	663,300	33,000	36,400	221,300	38,300	26,400	8,500	10,200	13,900	2,400	26,100	20,900	3,700	8,300	6,100	291,000	2,444,700	006.17
MARCH	130.000	100	000,6	131,200	2,100	12,900	3,000	76,900	65,700	87,700	27,400	8,300	5,100	20,300	197,000	2,900	4,700	53,800	7,000	62,900	63,700	381,000	27,700	56,600	95,300	25,100	23,300	4,800	2,400	6,300	1,400	7,200	4,700	27,200	1,643,000	18.20
FEBRUARS	7.700	004	1,000	72,800	8,600	13,900	3,800	33,500	208,500	14,600	8,400	9,000	9,000	15.700	181,00	1,900	3,500	8,90	8,000	15,300	29,200	215,000	125,800	14,500	116,200	38,100	140,800	6,700	4,200	1,600	3,700	15,500	12,600	19,900	1,387,500	40.810
JANUARY	001.11	909	19,600	35,000	7,700	17,400	3,200	14,200	234,800	22,500	8,200	8,300	18,200	53,900	27,600	1,700	3,500	39,500	11,400	10,400	2,800	14,200	33,000	30,600	29,700	18,300	7,900	4,400	4,800	1,700	11,500	2,700	4,200	2,900	810,500	23.840
YEAR	1001	25	96.	27	28	59	1930	2	, ex	33	34	35	36	37	98	39	1950	17.	3		1		9.	14	æ.	64	1950	Z,	X	53	た	55	K	1957	Total	Mean

TABLE 33
ESTIMATED MONTHLY AND ANNUAL FLOWS IN ACRE-FEET AT LAVON RESERVOIR - EXISTING (1998) CONDITIONS

YEAR	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	TOTAL
1924	11.800	9.950	65,680	28.450	36.360	8.410	980	0	0	0	0	0	161.530
25	202	1.120	09	6.90	28.760	1.230	80	0	0	1.040	95	0	30,840
56	5.440	510	10.150	36,500	43,860	61,750	177,970	10,060	3.030	10,250	8.710	47.730	415.960
27	34,600	35.360	79,550	112,360	29,030	22,740	77,210	1,780	840	18,960	1,830	15,100	1,26,360
28	7,490	34.340	10,150	112,990	23,570	23,930	9,070	820	30	04	2,790	64,590	289,810
53	50,160	38,110	32,25	24,720	156,400	25,530	2,260	30	8	370	1,540	1,180	332,920
1930	710	3,070	1,730	10,040	100,380	2,410	1,160	0	0	044	2005	13,820	134.260
2	1,180	004,6	29,720	15,420	12,460	13,950	100	044	140	1,230	0	2,300	86,340
SX	227,400	115,950	17,080	5,110	17,520	6,100	24,200	13,040	5,780	1,900	310	40,530	504,920
33	50,260	14,770	68,950	18,770	49,910	11,750	710	1,970	1,970	230	2,220	1,370	222,580
3	10,210	14,790	43,760	38,650	25,270	2,300	10	0	10	0	1,490	9	136,550
35	13,130	2,730	6,140	18,010	167,450	185,340	3,220	8	074,4	7,110	23,030	35,030	468,810
36	6,720	4,820	3,260	1,130	5,650	1,560	130	0	10,090	26,550	9,750	17,230	86,890
37	67,180	10,880	30,340	15,110	4,100	1,840	30	9,200	1,020	3,150	5,530	34,650	183,030
38	000,611	175,990	000,98	73,700	6,220	16,260	230	10	0	0	0	0	487,410
39	0	2,260	10,530	109,790	4,380	14,760	720	30	0	300	0	04	142,540
1940	8	1,380	770	069,06	74,060	47,590	48,030	1,630	220	0	16,180	96,630	377,270
17	30,190	38,020	30,780	78,820	1,580	192,350	18,570	8,440	810	3,780	2,690	16,840	503,870
¥	4,830	4,610	6,930	347,750	004,49	68,210	2,920	049	5,230	6,380	14,690	16,840	543,430
43	8,450	0,640	73,830	41,620	55,130	60,800	1,70	0	0	540	30	140	248,590
#	28	10,710	1,980	16,820	112,620	7,710	360	0	059	202	1,990	19,610	216,110
45	21,210	185,420	207,560	86,170	13,750	119,400	48,300	930	3,470	52,330	10,220	3,790	752,550
3	25,950	102,960	45,530	16,040	167,070	106,780	1,70	1,760	1,320	024	254,140	131,200	854,930
14	27,640	7,160	26,690	28,490	42,230	24,590	980	8,280	1,510	096	4,330	61,380	234,120
9	38,660	75,270	45,870	6,620	76,770	7,380	8,810	8.	0	0	0	10	259,480
64	93,480	76,710	52,140	23,250	50,850	26,010	570	9	0	22,170	2,050	1,540	348,810
1950	86,98	165,980	16,930	19,710	149,850	38,870	39,010	12,680	72,920	3,970	1,480	1,480	589,750
Ŋ	1,3	21,320	5,730	5,140	13,000	172,130	12,350	120	10	0	0	20	231,360
8X	3	150	01	39,730	27,420	4,130	0	0	0	0	1,490	4,050	77,450
53	2,280	1,090	11,470	65,780	88,410	1,350	0	0	0	1,350	3,930	4,030	179,690
太	20,560	6,680	2,600	22,380	62,250	12,070	0	1,370	2,050	10,390	3,840	510	144,700
55	2,470	11,730	19,950	13,630	10,750	6,210	3,160	720	7,680	1,750	980	250	76,450
×	2,100	13,830	2,370	5.70	31,170	926	2,070	2,210	430	1,490	4,260	1,770	68,360
1957	1,700	2,120	12,690	276,510	380,260	24,4%	280	2,890	4,010	4,380	85,220	21,260	847,770
Total	954,030	1,205,890	1,112,900	1,812,530	2,208,860	1,352,840	516,120	79,270	124,770	181,300	470,680	655,250	10,674,440
Moor	ogo go	25 1470	20 730	012 53	OTO 413	20 700	16 180	0 330	3 670	6 330	13 Rho	020 01	030 010
The state of	20,00	33,410	×, 130	73, 250	016,40	35,130	73,100	5,330	2,010	2,330	13,040	13,610	343,430

TABLE 34. ESPIDATED MONTHLY AND AUNUAL FLOWEIN AGRE-FERN AT BARDWELL DAMSITE - EXISTING (1998) CONDITIONS

7,120 1,000 1,000 1,000 1,000 1,1000	, didi giringingingingingingingingingingingingingi	2, 46 11, 183 13, 92 13, 92 13, 92 13, 92 13, 93 13, 93 13, 93 13, 93 13, 93 14, 14 14, 14 15, 14 16, 14 17, 18 18, 18	10,190 8,1720 8,1720 6,640 36,610 1,040 7,700 7,700 1,220 1,220 1,600 1,600	4 88 84 65 85 85 88 88 88 88 88 88 88 88 88 88 88	2, 2, 3, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8,	2,775 3,286 3,286 1,980 1,980 2,980	41,1,1,4, 88, 88, 88, 88, 88, 88, 88, 88, 88,	2, 1, 2, 2, 2, 2, 3, 3, 3, 4, 4, 4, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5,	276 246 7,310 6,046 6,046 6,100 10,400 1,400 1,400 1,400 1,400 8,770 8,770 8,770 2,800 2,8	\$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$
	4. 4.4.4.4.4.4.4.4.4.4.4.4.4.4.4.4.4.4.	838 13,528 3,138 3,138 3,138 3,138 1,438 1,440 1,438 1	200 200 200 200 200 200 200 200 200 200	4 8.	2, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,	3, 198 2, 245 180 180 180 680 680 680 680 7, 198 875 7, 198 876 876 876 877	8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	6,146 1,246 1,246 2,050 2,050 2,050 1,050 1,050 1,050 1,050 1,050 1,050	2.50 7, 73.10 10,000 10	9,5% 8,5% 8,5% 8,5% 8,5% 8,5% 8,5% 8,5% 8
	⁴ ⁴ ⁴ ⁴ ⁴ ⁴ ⁴ ⁴	14,210 3,388 3,388 3,388 3,588 3,588 3,588 3,788 3,188 5,188 1,4,288 1	8,788 9,788 9,668 9,668 9,788 1,	4. K. 8. 8. 8. 8. 8. 8. 8. 8. 8. 8. 8. 8. 8.	88. 10.037 10.03	3,246 120 120 120 12,450 14,96 14,966 14,966 16,966	2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2	2, 2, 698 698 808 808 11, 288 11, 288	7,330 6,746 6,746 10,000 1,000	\$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$
	ઌૢ૿ઌૢઌૢઌૢ૽ૢઌૢ૽૱ૢઌૢ૽ઌૢ૾૱ૢઌૢ૽ૢઌૢઌ ૹૹૹૹઌૢઌૢઌૢઌૢઌૢઌૢઌૢ ૹૹૹૹૹૹૹૹૹૹૹૹ	13.88 3,188 3,188 3,982 3,982 3,982 5,733 6,000 1,433 8,000 1,433 1,400	8,50,000 1,0	8558 858 858 858 858 858 858 858 858 85	1, 370 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1	280 680 74,590 76,44,490 76,650 76,650 76,650	88. 4. 988. 888. 888. 888. 888. 888. 888	2,050 870 870 870 870 280 280 1,1280 1,340 1,950	756 6,046 10,000 10,000 1,000	88,888 88
	ઌૣઌૢઌૢઌૢ૽૱ૢઌૢૹૢ૽૱ૢઌૢ૽૽૽ૢ૾ૢઌૢઌ ઌઌૹઌૢઌૢઌૢઌૢઌૢઌ ઌઌૹઌૢઌૢઌૢઌૢઌૢઌૢઌૢઌૢઌ	3.188 7.738 8.098	6,646 38,610 1,046 7,39 20,739 1,220 1,1,690 11,1,690	3,75 2,88 3,88 3,88 3,88 3,88 3,88 3,88 3,88	1,100 100 100 100 100 100 100 100 100 10	1880 620 620 620 620 620 620 620 620 620 62	2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2	2,050 870 870 870 1,050	6,040 10,000 10,000 1800 1900 1900 1900 1900 1900 1900 1	28,588 28,588 38,588 38,588 38,589 39
	ઌૣૡૢ૽૱ૢઌૢ૽૱ૢઌૢ૽૽ૣૡૢઌૢઌૢૺૺઌૺ ઌૹૢઌૢઌૢઌૢઌૢઌૢઌૢઌૢઌૢઌૢઌૢઌૢઌૢઌૢઌૢઌૢઌૢઌૢઌૢ	7.038 2.038 2.0398 2.03	38,610 1,046 1,046 1,126 3,910 3,910 1,1,690 1,1,690 1,1,690 1,1,690	3,688 888 888 888 888 888 888 888 888 888	128 8 8 8 9 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	620 17,450 280 280 280 280 280 280 4,940 4,940	2, 2, 388 388 1, 588 389 1, 58 1, 58 1, 58 1, 58	2,050 840 840 280 1,00 1,00 1,00 1,00 1,00 1,00 1,00 1,	86,01 88,01 88,198 81,788 87,788 88,88	8,559 126,330 33,350 33,350 33,350 33,350 34,350 36,510
	ૡૢૡૢઌૢ૽૱ૢૡૢૡૢૺઌઌૢ ઌૹઌ૿ૹ૽ૢ૱ૢૡૢઌૢઌૢઌ ઌૹઌૹ૽ૢૹ૽ૢૹ૽૽ૢ૽૱ૢૡૢઌૢઌૢઌૢઌ	4. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2.	7, 986 7, 1986 7, 1996 7, 1996 19, 686 19, 686 19, 686	\$	8,8,8,6,0,8,8,8,8,8,8,8,8,8,8,8,8,8,8,8,	0,4 1,7 2,8 2,8 2,4 4,7 5,5 6,5 6,4 4,4 5,5 6,5 6,5 6,5 6,5 6,5 6,5 6,5 6,5 6,5	2,896 788 788 788 1,40 75 8,88 1,50 0	870 280 1,220 1,350 1,950	10,000 1,198	28,88 126,630 37,380 33,280 42,280 42,180
	૱ૢ૽ૺઌૢ૽ઌ૽ૢ૽૱ૢ૱૽ૢ૽ૢ૽ઌ૽ૣઌૢ૽ૹૢૺઌ૾ૢઌૢ ૹૢૡૹૢૹૢ૱ૢઌ૽ૢ૽૽ૢઌ૽ૣઌ૽ૢૹૢૹૢઌૢઌ ૹૢૡૹૹૹૹૹૹૹૹૹૹૹૺઌૺૺૺૺઌૺૺૹૹૹૹૹૺૺૺઌૺૺૺઌૺ	5,598 5,738 5,738 5,738 5,738 5,738 5,738 5,738 5,738 5,618	1,046 7,588 7,780 3,910 1,580 1,690 10,090	9,50,00,00,00,00,00,00,00,00,00,00,00,00,	8 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9	7,458 888 889 889 7,577 75 75 8	5% 300 1140 2,410 8,880 0	280 1,220 1,950 1,950	198 198 198 198 198 198 198 198 198 198	29,630 126,300 37,350 39,920 83,210 42,510
	1, 1, 1, 1, 2, 2, 2, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,	10,988 2,038 2,038 2,037 3,038	20 77 73 73 73 73 73 73 73 73 73 73 73 73	8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	0.000 0.000	7,450 280 280 280 1,570 4,940 2 2	300 140 2,410 8,880 1,50	190 190 1,950 1,340 1,090	88 1 1 1 88 8 8 8 8 8 8 8 8 8 8 8 8 8 8	126,300 37,350 39,980 83,210 42,150
	ઌૢઌૢૻ૱ <u>ઌૢઌ૿૽ૢ</u> ૡૢૹૢ૽૱ૢઌૢ૽ઌૢ૽ઌૢ ૡૢૹૢૹૢઌૢઌ	8,8,9,8,8,7,8,7,8,7,8,7,8,7,8,7,8,7,8,7,	20,778 3,910 1,220 1,500 10,600 18,230	198 80,020 3,080 200 200 200 200 200 200 200 200 200	96080 136080 1408080	298 288 289 24,94 275 275 275 275 275	2,410 8,880 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	1,220 1,950 1,950 1,090	190 1,620 8,730 5,320 2,80	37,350 39,920 83,210 42,510 42,160
	8,4 8,4 8,6,4,4,6,6,8 8,6,4,4,6,6,8 8,6,6,6,6,6,6,6,6,6,6,6,6,6,6,6,6	2,230 2,730 1,060 1,060 1,000 1,400 1,400 1,400 1,400 1,400	20 3,270 1,220 1,4,600 10,000	6,020 3,080 200 200 570	200 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	2000 11,570 4,940 270 270	2,410 8,880 8,00 1,50	1,950	1,620 8,776 2,320 2,82 2,82 2,82	39,920 83,210 42,510 42,160
	.,030 1,030 1,110 1,110 1,030	25,730 746 746 746 740 740 740 740 740 740 740 740 740 740	20, 780 3, 910 1, 220 1, 4, 690 10, 690	6,020 3,080 200 970	360 180 180 100 100 100 100 100 100 100 10	2,570	2,410 8,880 0 0 150	1,950	8,776 8,776 2,80 2,80 2,80	83,210 42,510 42,160
		5,746 5,100 1,066 1,900 1,4,010 1,8,010 1,8,010	3,910 1,220 1,4,690 10,090 10,090	3,080	180 110 250 250 250	272	8,880 150 01	1,090	8,7 28,0 28,0 8,0 8,0 8,0 8,0 8,0 8,0 8,0 8,0 8,0	12,510 12,160
	, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,	1,000 1,000	1,220 1,650 10,090 18,090	970	410 250 250 250	0200	150	1,090	5,320	42,160
	(2) 10 (2) 10 (2) (3) (3) (3) (3) (3) (3) (3) (3) (3) (3	5,100 1,900 1,4,010 1,910 1,910 1,510 1,510	3,600 14,690 10,090	970	410 20 250 250	2000	150		280	
	6,6,8,8,8,8,8,8,8,8,8,8,8,8,8,8,8,8,8,8	1,900 6,430 1,010 18,910	14,690 10,090 18,230		22.020	00	00	250	1 (97.380
	13,830 66,036 5,578	6,430 14,010 18,910	10,090	020	2,220	0	10	0	0	26,130
	86,036 5,036 5,576 5,576	18,010	18.230	15,480	2.220		24	21.850	17,350	85,680
	66,030 5,570 68	18,910		10,290		130	3,200	920	2,280	103,740
	5,570	15 330	060,11	680	3,810	13,860	10,100	4,840	6,480	140,570
	200	777330	7,810	904	10	12,220	3,460	80	047	75,370
	30,13	48,410	9,660	980	9	9	140	1,240	069'6	95,990
	24,950	2,070	26,730	8,520	370	8	3,090	1,96	340	147,380
	2,570	12,50	8,930	320	1,920	330	140	8,100	3,580	63,640
	8,800	1,430	11,660	180	890	1,930	130	630	6,950	47,720
	2,930	18,520	1,340	2,440	0	0	0	20	04	39,510
	4,070	5,810	2,410	210	110	0	350	30	20	31,340
	7,590	10,380	800	240	09	130	0	0	0	38,840
	3	001	8,260	9	0	0	0	0	0	9,920
	18,350	10,790	340	10	0	0	0	2,220	6,780	39,040
	1,920	16,920	2	200	10	20	210	110	2002	26,830
	120	2,290	0	0	0	0	310	024	0	3.760
	1,250	1,660	1,630	0	98	1,540	20	0	0	8,890
	8	2,720	266	0	100	20	9	2,020	140	7.510
	016,44	36,440	5,810	8	30	130	7,610	20,720	1,590	119,980
235,290 245,180	336,880	384,170	255,760	62,830	18,370	8, 33 St. 53	51,820	85,980	113,030	2,004,910
4 300	0000	11 300	7 530	000	C-fu	6	,	0	000	O. C.
orsil nakio	21,940	44,300	1,300	T,0%1	₹	1,550	1, X0	2,530	3,320	X

TABLE 35 ESPIDACED MONTHLY AND ANNUAL FLOKE IN ACRE-FRET AT NAVARRO MILLS DAWSTTE - EXISTING (1958) CONDITIONS

19,800 12,340 19,800 12,340 19,600 19,640 19,130 1	YEAR	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	TOTAL
13, 19, 18, 18, 18, 18, 18, 18, 18, 18, 18, 18	1786	19.800	12.840	38.610	12.940	0,640	19.310	30	100	4,910	240	260	780	119,160
13.3 13.5 13.6 13.5	25	190	8	50	270	1,460	0	120	140	330	2,570	10,810	410	16,410
15.50 15.5	56	13,130	1.820	23,320	23,810	27,740	4,850	8,060	6,790	5,800	2,070	2,220	13,330	132,940
1,500 1,50	27	12,250	12.840	23,030	23,320	27,150	15,090	1,400	099	360	8,170	009	1,370	126,240
1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,	28	390	7,600	8,830	8,960	5,670	11,930	6,260	2,880	310	0	1,220	10,770	64,820
1,000	50	16.460	2,700	13,430	9,310	12,740	78,890	1,370	220	1,110	430	3,640	10,880	151,180
1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,	930	3,220	14,990	5,850	2,340	111,820	14,500	860	30	0	5,160	1,550	18,820	179,140
2, 500 5, 1, 100 6, 770 2, 270 1, 5, 60 770 350 350 370 30 1, 560 370 30 1, 560 370 30 1, 560 2, 100 2, 200 2, 100 2, 200 </td <td>17</td> <td>5,480</td> <td>12,030</td> <td>12,130</td> <td>7,770</td> <td>10,570</td> <td>1,840</td> <td>810</td> <td>80</td> <td>340</td> <td>1,070</td> <td>200</td> <td>160</td> <td>53,380</td>	17	5,480	12,030	12,130	7,770	10,570	1,840	810	80	340	1,070	200	160	53,380
E2, (20) 2,500 11,500 6,980 13,780 130 540 540 2,400	, Qu	41,580	95,140	66,730	2,270	20,990	10,000	770	360	13,560	530	0	320	252,250
6.89 3,200 17,350 17,350 17,350 17,350 18,350 18,470 19,470 19,470 19,470 19,470 19,470 19,470 19,470 16,470 <td>33</td> <td>22,020</td> <td>2,520</td> <td>14,550</td> <td>6,890</td> <td>6,980</td> <td>13,780</td> <td>340</td> <td>250</td> <td>520</td> <td>240</td> <td>340</td> <td>340</td> <td>090,69</td>	33	22,020	2,520	14,550	6,890	6,980	13,780	340	250	520	240	340	340	090,69
1,560 11,470 6,540 7,180 10,570 11,450 10,780 6,590 15,17	34	6,890	3,200	17,350	36,460	4,820	1,390	150	0	340	80	2,160	2,890	75,730
1,596 1,330 1,30	35	7,690	11,470	6,940	7,180	45,770	41,450	10,780	650	2,810	4,310	3,490	16,170	158,710
86, 460 6, 590 124, 400 6, 470 1, 1280 6, 417 1, 410 10 10 10 10 10 10 10 10 10 10 10 10 1	36	1,590	1,330	1,300	009	10,290	066,9	5,500	310	8,820	16,470	7,740	16,070	77,010
2,550 10,400 10,100 10,700 </td <td>37</td> <td>26,460</td> <td>6,590</td> <td>24,400</td> <td>6,270</td> <td>1,880</td> <td>2,170</td> <td>340</td> <td>0</td> <td>0</td> <td>0</td> <td>1,950</td> <td>9,500</td> <td>19,560</td>	37	26,460	6,590	24,400	6,270	1,880	2,170	340	0	0	0	1,950	9,500	19,560
2,240 7,250 4,460 1,170 5,010 40,840 900 0	38	36,550	30,480	16,170	89,670	9,100	6,430	1,740	730	200	560	430	510	192,570
10,586 45,086 29,390 15,184 2,039 4,100 13,339 59 190 31,390 31,390 31,316 31,390 3	39	2,240	7,250	094,4	1,170	5,010	0,840	8	0	0	0	0	0	61,870
10,580	046	0	720	30	17,840	2,030	4,100	13,330	25	0	0	73,890	31,160	143,150
1,000 1,1150 102,370 102,470	41	10,580	45,080	29,890	15,190	29,890	39,300	36,950	86	130	3,130	094	1,300	212,950
13,250 830 8,420 10,770 13,450 8,720 400 20 30 14,750 5,500 1,500 28,310 36,320 24,570 6,810 106,720 28,810 28,810 3,220 1,480 21,580 1,570 10,700 28,310 36,320 24,570 24,100 24,100 28,810 28,820 1,480 21,580 3,900 10,700 28,310 36,320 24,570 24,100 24,100 26,120 26,820 24,220	3	910	850	1,150	102,370	9,160	8,450	510	200	30,390	6,440	8,620	12,180	181,430
18,810 37,130 12,570 6,810 106,720 8,820 400 3,220 1,480 11,590 10,790 10,790 10,790 14,410 28,930 94,420 15,240 80,890 15,240 14,410 15,240 10,790 10,790 10,790 10,790 14,410 15,220 14,420 13,520 15,720 10,730 1	43	3,250	830	8,420	10,770	53,450	8,710	240	20	330	14,750	50	1,500	102,320
28,510 35,930 94,640 51,960 2,410 15,540 28,810 3,220 1,480 21,580 1,900 10,790 10,790 14,310 28,910 13,520 6,320 6,330 6,330 6,330 1,220 10,730 10,730 10,730 10,730 10,730 10,730 10,730 10,230 10,7	1	18,810	37,130	12,570	6,810	106,720	8,620	004	20	0	0	1,510	14,060	206,650
14,310 28,910 13,520 6,120 80,850 8,290 480 730 100 150 10,7760 5,900 14,310 28,930 6,120 6,126 2,220 0 0 0 0 0 0 0 0 0	45	28,510	36,930	5,640	51,980	2,410	15,540	28,810	3,220	1,480	21,580	3,900	10,790	299, 790
48,220 4,480 30,580 28,930 6,380 3,280 30 70 0 230 1,080 1,280 2,720 0 <td>29</td> <td>14,310</td> <td>28,910</td> <td>13,520</td> <td>6,120</td> <td>80,850</td> <td>8,290</td> <td>1480</td> <td>130</td> <td>100</td> <td>150</td> <td>10,780</td> <td>2,900</td> <td>170,140</td>	29	14,310	28,910	13,520	6,120	80,850	8,290	1480	130	100	150	10,780	2,900	170,140
1,840 2,780 16,760 2,930 61,740 650 2,220 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	24	48,220	4,480	30,580	22,930	6,380	3,280	30	0	202	0	0	230	116,200
1,086 1,520 4,130 4,140 5,660 2,240 1,980 260 0 2,280 20 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	29	840	2,720	16,760	2,920	61,740	650	2,220	0	0	0	0	0	87,850
1,772 30,360 1,360 15,620 6,040 1,060 850 0 199 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	64	1,080	1,520	4,130	4,140	2,660	2,240	1,980	560	0	2,280	50	0	23,310
100 1,270 80 120 1,610 8,690 20 0 3,860 0 1,810 10,200 10,200 10,400 2,710 10,200 10,200 10,400 2,710 10,200 10,200 10,400 10,400 2,710 10,200 10,200 10,200 10,400 2,710 10,200 10,200 10,200 10,400 10,400 2,710 10,400 1,710 2,260 10 0 1,00	950	1,720	30,360	1,360	15,620	0,040	1,060	850	0	180	0	0	0	57,200
0 1.640 2.5,30 19,700 19,110 460 110 0 0 0 0 1,400 10,200 10,200 13,530 680 28,610 5,840 80,490 320 450 0 0 1,400 2.710 500 7,340 10,200 10 0 1,400 1,400 1,400 1,500 2,540 31,40 230 760 590 230 2,30 10 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	17	100	1,270	80	120	1,610	8,690	20	0	3,860	0	0	0	15,750
3,530 680 28,610 5,840 80,490 320 450 0 1,400 2,710 500 7,340 10 3,540 50 30 1,400 2,710 500 7,340 10 10,340 50 10 10,400 10 10 10,340 1	X	0	1,640	.2,930	19,700	19,110	094	110	0	0	0	1,810	10,200	55,960
3.960 4,50 4,10 4,380 1,50 9,100 2,40 3,140 230 10 0 140 490 10 10 10 10 10 10 10 10 10 10 10 10 10	53	3,530	089	28,610	5,840	80,490	350	720	0	1,400	2,710	200	7,340	131,870
10, 360 12,720 15,500 25,540 3,140 230 760 590 230 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	な	3,960	20	30	210	9,100	50	0	10	0	140	064	10	14,020
650 5,620 0 0 0 5,330 410 62,570 15,940 160 0 0 0 5,330 410 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	55	410	4,410	4,380	1,500	2,540	3,140	230	160	266	230	0	0	18,190
7 250 6,730 8,230 167,110 62,570 15,540 160 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	18	650	5,620	0	20	26,170	2,260	10	0	0	0	5,330	410	40,470
. 352,770 432,820 534,430 690,420 877,550 400,130 126,210 20,250 78,310 93,010 144,270 197,700 3	156	250	6,730	8,230	167,110	62,570	15,540	160	0	0	0	0	0	260,590
10,380 12,730 15,720 20,310 25,810 11,770 3,710 600 2,300 2,730 4,240 5,810	tal	352,770	432,820	534,430	690,420	877,550	400,130	126,210	20,250	78,310	93,010	144,270	197,700	3,947,870
	28.0	10.380	12.730	15.720	20.310	25,810	11.770	3.70	009	2,300	2,730	4.240	5.810	116,110

TABLE 36

ESTIDACISD MONTHLY AND ANNUAL FLOAS IN ACRE-FEET AT TENNESSEE COLONY DAMETTE - EXISTING (1958) CONDITIONS

TOTAL	308 000	100,000	2 164,000	2,729,500	1,388,000	2.971.100	2,988,700	1,220,800	4,896,500	1,777,000	1,056,300	3,331,500	1,561,500	1.271,300	4,028,600	548.100	2,231,600	5,715,700	6,480,000	2,097,000	3.716.700	7,558,800	5,126,900	2,067,100	2,067,800	2,053,900	3,844,800	536,400	789,200	1,341,200	376,300	536,000	397,000	6,783,400	88,446,800	
DECEMBER	0000 9	3,5	215,700	21,300	250,900	177,100	342,000	96,700	19,400	20,200	75,600	341,000	233,800	157,900	8,000	5,200	790,700	102,500	114,300	23,600	120,200	129,700	516,900	263,100	14,200	34,800	22,200	11,000	135,500	68,600	26,300	13,800	14,000	199,700	4,516,000	
NOV EMBER	14 500	173 300	29,100	0	27.700	51,900	27,700	33,900	11,800	3,300	33,500	000,64	200,600	37,600	000,6	2,700	7,50,600	148,300	177,000	11,300	31,000	006.06	896,500	43,900	7,600	120,800	M8,600	11,400	35,600	13,300	68,300	9,000	45,500	630,100	3,535,300	
OCTOBER	000.4	60,600	45.100	165,300	1,900	15,800	166,200	17,500	10,400	8,200	2,500	006,69	596,300	16,700	10,500	1,300	3,200	152,800	180,200	156,100	18,000	275,300	26,800	26,600	10,700	42,500	70,900	4,800	6,200	11,200	80,300	15,700	9,900	268,900	2,549,300	
SEPTEMBER	77 .300	0000	160,000	9,500	5,200	23,100	2,000	7,000	285,900	45,800	7,400	50,300	7,600	15,900	9,300	1,400	7,400	51,800	205,900	33,000	25,000	44,900	94,100	109,700	13,100	12,400	394,400	15,600	0	13,800	5,500	24,300	6,500	20,400	1,809,500	
AUGUST	3.000	1.400	163,500	10,000	61,200	4,800	1,600	6,100	0	54,500	2,100	7000,000	2,900	0	22,500	3,800	15,700	123,300	155,000	4,000	7,900	006'64	50,800	15,200	12,600	12,300	167,700	5,700	0	11,000	11,600	17,100	4,700	385,600	1,424,500	-
JULY	2.000	3.800	134,200	97,500	143,100	18,800	10,900	16,600	124,800	7,100	3,900	354,300	85,900	5,300	34,800	29,100	387,200	1,036,800	319,000	19,000	24,900	591,300	106,100	68,100	93,600	40,100	104,000	18,900	5,200	14,800	0	14,000	6,400	1,62,200	4,383,700	
JUNE	289.100	2,600	141,600	228,300	599,300	1,162,800	279,000	29,200	192,700	284,900	18,200	1,026,900	135,100	57,400	87,700	188,700	215,900	1,340,700	1,001,500	654,600	405,800	676,100	1,160,900	148,300	54,300	523,100	167,900	272,600	146,500	22,700	0	50,700	21,600	1,870,300	13,160,000	2000
MAY	229,400	208,500	296,100	453,200	121,000	673,200	1,765,100	168,900	708,900	288,600	74,000	917,900	204,600	56,900	200,800	93,600	204,000	765,900	2,479,900	525,300	1,875,600	395,400	612,800	137,700	579,800	360,800	974,400	58,200	274,000	776,300	74,200	94,300	180,600	2,107,900	18,607,800	2000
APRIL	296,200	0	397,000	672,200	190,600	198,700	34,300	193,900	63,100	148,400	439,100	99,600	8,500	93,500	1,601,200	7,700	117,800	272,700	1,630,200	413,400	117,200	2,698,100	164,900	488,600	139,500	227,200	367,300	28,600	99,300	4,100	25,400	82,900	15,000	676,700	12,062,900	art. moo
MARCH	875,000	11,900	340,300	575,800	130,400	257,100	89,900	330,700	1,149,400	481,200	236,700	106,900	18,100	364,500	638,700	65,300	12,800	656,200	74,200	29,500	267,600	1,821,100	575,700	287,900	756,700	558,500	151,600	36,700	42,300	283,800	15,300	84,800	14,700	61,000	11,732,300	ofer one
FEBRUARY	215,300	8,300	29,100	283,700	104,300	119,400	220,700	247,100	1,819,900	57,600	41,300	166,300	20,300	111,900	841,400	104,500	27,000	431,800	79,200	45,100	322,100	333,300	643,100	102,000	146,800	121,400	1,194,300	009,94	29,100	26,400	19,400	85,000	26,400	58,000	8,155,100	070 000
JANUARY	312,000	11,800	212,300	212,700	25,400	268,400	46,300	103,200	810,200	371,200	105,000	109,400	44,800	383,700	26,70	44,800	2,300	632,900	63,600	152,100	204,400	452,800	278,300	376,000	238,900	0	181,500	26,300	15,500	95,200	20,000	14,400	21,700	12,600	6,510,400	100
YEAR	1924	25	56	27	28	53	1930	#	N.	33	34	33	30	37	38	36	1940	7.	45	£3	#.	45	46	47	8	64	1950	Z,	X	53	去	55	98	1961	Total	***

- 89. SEDIMENT DEPOSITION IN RESERVOIRS. Estimates of average annual rates of sediment deposition for Corps of Engineers Reservoirs, existing or under construction, in the Fort Worth District were made in connection with definite project studies or the preparation of preconstruction design memoranda for the respective projects. In each case, the estimates of sediment inflow to the reservoirs were based on the latest data available at the time of these studies. Generally, the average rate of sediment production was estimated for the contributing watershed area above each reservoir. This was based on the results of reservoir resurveys by federal agencies (Reservoir Sedimentation Data Summary Sheets), published by the Subcommittee on Sedimentation, Federal Inter-Agency Committee on Water Resources, and published results of suspended sediment measurements such as "The Silt Load of Texas Streams," (annual reports by the Texas Water Commission, formerly known as the Texas Board of Water Engineers). In some instances, these were augmented by suspended sediment samples obtained by the Corps of Engineers. For some of the reservoir projects the anticipated average rate of sediment production and deposition was coordinated with the Soil Conservation Service, United States Department of Agriculture, and adjusted to reflect the effects of authorized major soil conservation programs. Sufficient storage space was originally provided in each reservoir for about 50 years of sediment deposition from beginning of deliberate impoundment. The most recent data contained in the publication, "Inventory and Use of Sedimentation Data in Texas," (Bulletin 5912, Texas Water Commission) were used to estimate sediment deposition for the new reservoir projects considered in this report. Methods set forth in Bulletin 5912 were also used to compare provisions for sediment deposition in the existing projects. The recomputed values were found to be generally in close agreement. Where required, allowances were made for the effects of existing and proposed land improvements and reservoirs on the watersheds. Subsequent to the completion of detailed hydrologic studies it was determined desirable that adequate storage be provided for accumulation of 100 years of sediment. However, only in Lakeview and Tennessee Colony Reservoirs were sediment allowances increased to meet 100-year requirements. The 50-year allowances for sediment deposition in the other reservoirs were not changed but will be reconsidered and proper revisions in sediment deposition will be made at the time of preconstruction planning. At that time, it is proposed to allocate sufficient storage for 100 years of sediment deposition in all new reservoirs and to recompute the effects of the 50-year sediment storage provided in existing reservoirs on the yields of these reservoirs.
- 90. SEDIMENT UNCONTROLLED DRAINAGE AREA. A study of the uncontrolled drainage area above Tennessee Colony was made assuming that the presently existing, under construction, and recommended reservoirs would be in the system upstream from Tennessee Colony under the multi-purpose project conditions. The sediment production rate for the uncontrolled drainage area between the existing and recommended system

of reservoirs and Tennessee Colony Reservoir was computed utilizing methods set forth in Bulletin 5912. The sediment production rates from the uncontrolled areas above the Livingston and Wallisville Reservoirs were likewise obtained. The sediment contributed from the uncontrolled area was augmented by estimates of sediment passed through the upstream reservoirs. The amount of sediment contributed by the upstream reservoirs was computed by determining the average trap efficiency for each reservoir ("The Trap Efficiency of Reservoirs," G. M. Brune, A. G. U., Volume 34, No. 3, June 1953) and applying this ratio to the sediment inflow estimated for the respective reservoirs. The combined total average annual sediment contribution above Tennessee Colony Reservoir, for example, was thus determined to be 1,900 acrefeet per annum; and 522 and 277 acre-feet per annum for the Livingston and Wallisville Reservoirs, respectively.

- 91. SEDIMENT DISTRIBUTION. The total sediment inflow estimated for each reservoir was distributed throughout the entire range of reservoir storage using the methods presented by W. M. Borland and C. R. Miller in Paper 1587 entitled "Distribution of Sediment in Large Reservoirs," Journal of the Hydraulics Division, Proceedings of the A. S. C. E., Volume 84, No. HY2, April 1958. These methods make it possible to distribute sediment in reservoirs of all shapes and sizes and facilitate the computation of new bottom elevations after deposition of the anticipated sediment.
- 92. SEDIMENT STORAGE. Table 37 presents pertinent data as to the amount of sediment storage provided in acre-feet and its distribution between the water conservation and flood-control pools of the existing and recommended Corps of Engineers reservoir projects.

TABLE 37

SEDIMENT STORAGE PROVIDED IN CORPS OF ENGINEERS PROJECTS
ON TRINITY RIVER BASIN

	:Se	diment a	storage (acre-	feet)	
	:	:]	In conser	va-:	In floo	od-
Reservoir	: Tot	tal: t	tion pool	:	control	pool
Lakeview (1)	45,6	500	43,100		2,500	0
Roanoke	26,		-		26,200	
Grapevine	16,0		14,300		1,700	
Aubrey	37,8	300	35,200		2,600	
Garza-Little Elm	40,	700	32,900		7,80	0
Tennessee Colony	(1) 190,0	000	160,500		29,500	0
Lavon (enlarged)	47,8	300	41,300		6,500	
Wallisville	12,8	300	12,800		-	
Benbrook (2)	15,		12,250		3,500	0
Grapevine (2)	36,0	000	27,300		8,70	0
Garza-Little Elm	(2) 53,5	500	40,100		13,400	0
Lavon (2)	47,8		41,300		6,500	0
Bardwell (2)	8,	700	6,000		2,700	0
Navarro Mills (2)			10,100		5,700	

- (1) 100-year sediment storage provided in this reservoir.
- (2) Existing project or project considered as existing.
- 93. CONSERVATION STORAGE. In determining the conservation storage capacity which should be provided in reservoirs investigated in the Trinity River Basin, cognizance was taken of the requests of local interests and of probable future water requirements of the region. Yield versus storage relationships were established and cost estimates were developed for varying increments of conservation storage. The storage allocations in the existing Grapevine and Garza-Little Elm Reservoirs were revised in accordance with requests from local interests assuming that comparable amounts of flood-control storage would be provided upstream in Roanoke and Aubrey Reservoirs.
- 94. A flood-prevention program, including floodwater-retarding structures for the Trinity River Basin has been prepared under authority of the Flood Control Act of December 22, 1944 (Public Law 534, 78th Congress, 2d Session). Data presented by the Soil Conservation Service in March 1961 indicate that a total of 1,200 retardation structures are proposed in the Trinity River Basin. Data as of January 1, 1961 indicated that 288 of these structures had been completed. The 1,200 structures in the Trinity River Basin, if constructed, would have a total detention storage of 1,072,621 acre-feet, a combined release rate of 31,828 second-feet, and would retard runoff from 3,679 square miles of drainage area. In addition, the 1,200 structures would contain

229,345 acre-feet of sediment storage. The number of existing and proposed retardation structures, the drainage area controlled, the sediment storage, detention storage, and combined release rates of the proposed retardation structures above each existing and proposed Corps of Engineers reservoir are shown in table 38. The completed structures, present land treatment practices and existing small ponds are reflected in the runoff utilized in determining dependable yields from the reservoirs under existing conditions of basin development. The completion of the proposed Soil Conservation Service land treatment practices, small ponds and retardation structures upstream from the reservoirs will result in an additional depletion of runoff into the reservoirs. The dependable yields from the reservoirs under 2020 conditions of basin development reflect this additional reduction in runoff.

TABLE 38

SUMMARY OF PERTINENT DATA FOR EXISTING AND PROPOSED SOIL CONSERVATION SERVICE RESERVOIRS

	: Numb	er of	: Tot	al p	roposed s	tructures	above re	servo	ir
	:str	ctures	3:		Drainage		:	0	
Reservoir	: com	oleted	:		area	:Sediment	Detenti	on:Cor	mbined
	:abov	res res	-:			d:storage			Lease
	:ervo	oir(1)	:Number	(2):	(sq.mi.)	:(ac~ft)	: (ac-ft) :	(cfs)
Benbrook		34	34		79.5	4,359	21,1	06	400
Grapevine		0	56		169.7	14,407	46,9	38	914
Aubrey		28	37		108.0	5,664	29,5	67	61.7
Garza-Little	Elm	28	120		439.3	24,457	122,1	25	4,094
Lakeview		3	27		115.3	9,902	34,1	60	925
Lavon		63	193		331.1	27,087	92,2	46	2,708
Bardwell		22	24		60.6	4,081	17,5	28	306
Navarro Mill	S	2	66		150.4	12,431	40,1	39	1,511
Tennessee Co		285	1,132		3,218.9	218,341	928,9	54 2	7,794
Wallisville		288	1,200		3,679.0	229,345	1,072,6	21 3	1,828

⁽¹⁾ As of January 1, 1961.

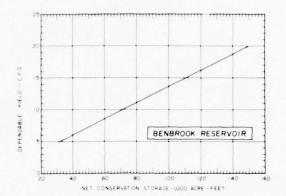
⁽²⁾ Includes completed structures.

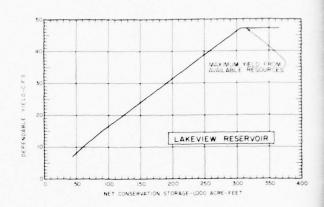
^{95.} The net conservation storages and yields from the existing and recommended Corps of Engineers reservoirs are shown in table 39 under existing and 2020 conditions of basin development as noted. Yield curves for these reservoirs under 2020 conditions of basin development are shown on plate 22. Refer to table 15 for dependable yields from existing and proposed local interest projects under 2020 conditions of basin development. The dependable yields shown in table 39 are based on recurrence of the 1950-1957 drought period on the basin. Under the 2020 conditions of basin development it is assumed that the proposed program of the Soil Conservation Service would be completed.

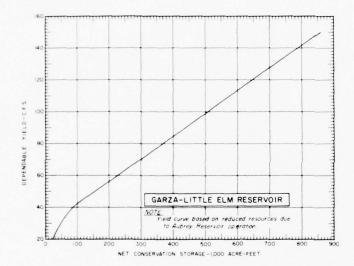
TABLE 39 RESERVOIR YIELDS CORPS OF ENGINEERS RESERVOIRS

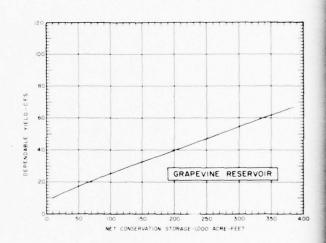
Reservoir	: Conservation: storage	Yie	Ld
	: (acre-feet)	: (cfs)	: (MGD)
XISTING RESERVOIRS UNDER EXISTING	(1958) CONDIT	TIONS OF BASIN	DEVELOPMENT
Benbrook	72,500	10	6.5
Grapevine	161,250	32	20.7
Garza-Little Elm	436,000	167	107.9
Lavon	100,000	71	45.9
Bardwell	29,500	8.4	5.4
Navarro Mills	53,200	32	20.7
Tennessee Colony (1)	1,032,500	735	475.0
Total	1,884,950	1,055.4	682.1
XISTING AND RECOMMENDED RESERVOIR	S UNDER EXISTI	ING (1958) CON	DITIONS OF
BAS	IN DEVELOPMENT	2	
Benbrook	72,500	10	6.5
Lakeview	306,400	52	33.6
Grapevine-Roanoke system	372,200	66	42.7
Garza-Little Elm -	31-)		
Aubrey system	1,234,400	291	188.0
Lavon (enlarged)	362,300	139	89.8
Bardwell	29,500	8.4	5.4
Navarro Mills	53,200	32	20.7
Tennessee Colony	1,032,500	705	455.7
Wallisville	-	(2)	(2)
Total	3,463,000	1,303.4	842.4
EXISTING & RECOMMENDED RESERVOIRS	UNDER 2020 COM	IDITIONS OF BA	SIN DEVELOPM
Benbrook	72,500	10	6.5
Lakeview	306,400	47	30.4
Grapevine -Roanoke system	372,200	65	42.0
Garza-Little Elm -			
Aubrey system	1,234,400	234	151.3
Lavon (enlarged)	362,300	121	78.2
Bardwell	29,500	6.5	4.2
Navarro Mills	53,200	28	18.1
Tennessee Colony	1,032,500	450	290.8
Wallisville	-,032,700	(2)	(2)
	2 1/52 000		
Total	3,463,000	961.5	621.5

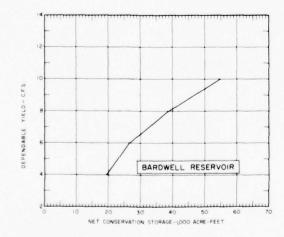
⁽¹⁾ Recommended project included in tabulation so that the overall effect of the recommended upstream development on the yield at Tennessee Colony may be evaluated.
(2) See footnote 4, table 4.

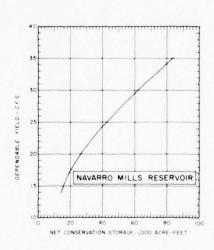


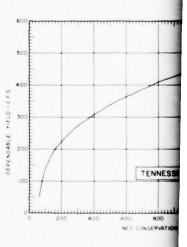












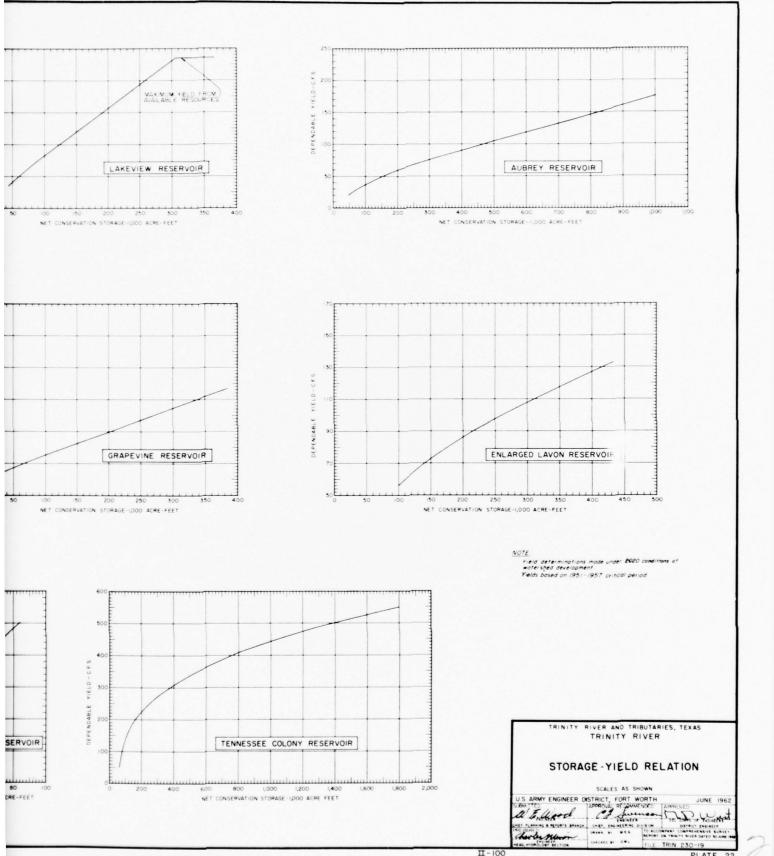


PLATE 22

96. FLOOD-CONTROL STORAGE. - Routings of the major floods of record (under 2020 conditions of basin development) were made through the system of reservoirs, assuming that all reservoirs would be at the top of the conservation pools at the beginning of the floods, and that releases would be regulated to the recommended operating discharges. Under these routing conditions the maximum flood-control storage utilized at Lakeview Reservoir was 135,600 acre-feet during the floods of April-July 1942 and the maximum flood-control storage utilized at Tennessee Colony Reservoir was 2,133,000 acre-feet during the floods of April-July 1957. Under the same routing conditions, the maximum flood-control storage was utilized in the recommended system of reservoirs on the Elm Fork watershed during passage of the floods of April-July 1957. The maximum flood-control storages utilized in the Elm Fork reservoirs were as follows: Garza-Little Elm Reservoir, 298,100 acre-feet; Aubrey Reservoir, 232,200 acre-feet; Grapevine Reservoir, 42,500 acre-feet; and Roanoke Reservoir, 216,100 acre-feet. Based on the above analysis, sufficient flood-control storage was provided in Lakeview, Tennessee Colony, Garza-Little Elm, Aubrey, Grapevine, and Roanoke Reservoirs to control the maximum flood of record. Period of record routings, based upon maximum utilization of conservation water, indicate that the conservation pool of Lakeview Reservoir would be filled infrequently. However, there is a possibility that conservation water in Lakeview Reservoir would not be used at the maximum rate, especially during its earlier operating period and that major floods could occur on a full conservation pool. A regional analysis of flood-control storage requirements was also made for the Trinity River Basin. The requirements for the 50-year flood-control storage taken from frequency curves based upon the regional analysis were in close agreement with the adopted flood-control storages for the recommended reservoirs. It is, therefore, considered that 50-year flood-control storage has been provided in the Lakeview, Tennessee Colony, Garza-Little Elm, Aubrey, Grapevine, and Roanoke Reservoirs. The flood-control storage provided in existing reservoirs on other subwatersheds was considered adequate in conjunction with the recommended increase in channel capacities downstream from these reservoirs. The storage allocations in the existing Grapevine and Garza-Little Elm Reservoirs were revised in accordance with requests from local interests assuming that comparable flood-control storage would be provided upstream in Roanoke and Aubrey Reservoirs. As a result of these studies the following net flood-control storages (in acre-feet and inches) have been provided in the existing and recommended reservoirs.

	:	Flood-cor	trol storage
Reservoir		(acre-feet)	: (inches)
Benbrook		76,550 (1)	3.3
Lakeview		136,700	9.4
Roanoke		223,700	6.9
Grapevine		47,300	9.9
Aubrey		258,300	7.1
Garza-Little	Elm	331,600	6.4
Tennessee Col.	ony	2,144,300	6.3
Lavon (enlarge	ed)	275,600	6.7
Bardwell		79,600	8.7
Navarro Mills		143,200	8.5

⁽¹⁾ Controlled storage at elevation 710.0. At the emergency spillway crest elevation 724.0 there is 170,350 acre-feet or 7.4 inches of flood-control storage provided.

Flood-control storage capacities provided in local interest projects are shown in table 4.

97. STANDARD PROJECT FLOODS. - The standard project floods for Aubrey, Garza-Little Elm, Roanoke, Grapevine, and Lakeview Reservoirs were determined in accordance with procedures set forth in EM 1110-2-1411 (Civil Works Engineer Bulletin No. 52-8, dated March 26, 1952, subject: "Standard Project Flood Determinations"). The standard project rainfall for the areas above each of the reservoirs was determined and loss rates applied as discussed in paragraph 102 to obtain rainfall excess values of 13.0 inches above Aubrey Reservoir, 11.5 inches above Garza-Little Elm Reservoir, 11.4 inches above Roanoke Reservoir, 10.9 inches above Grapevine Reservoir, and 13.1 inches above Lakeview Reservoir. The six-hour rainfall excess values were applied to the appropriate unit hydrographs given in tables 45 and 46 and the rainfall on the reservoir surfaces added to develop standard project flood hydrographs at each of the above damsites. In the case of Tennessee Colony Reservoir, it was estimated the standard project flood would be equivalent to one-half of the spillway design flood for the purposes of this report. The adopted standard project flood for each of the reservoirs was routed through the reservoir under the following conditions: (1) The reservoir level in each reservoir was assumed to be at the top of conservation pool at the beginning of the flood; (2) local runoff at downstream gages was assumed to be as computed for the flood of April-May 1957; and (3) the outlet works at each reservoir were assumed operative during the passage of the flood. Results of routing the standard project flood through each of the reservoirs under the above conditions are summarized in the following tabulation:

	Stand	ard project flood	:Maximum:Maximum :routed :reservoir	
Reservoir	Peak inflow (cfs)	: Volume : (acre-feet)		elevation (ft-msl)
Lakeview	168,400	194,500	69,400	528.7
Roanoke	159,300	372,200	129,400	
Grapevine	89,700	429,000	29,200	565.7
Aubrey	250,400	482,800	176,400	635.7
Garza-Little Elm	31.7,600	1,045,200	42,400	538.3
Tennessee Colony	475,900	5,017,400	289,000	285.0

- 98. FLOOD-CONTROL EFFECTS. In order to evaluate the floodcontrol effects of both existing and recommended Corps of Engineers reservoirs in the Trinity River Basin, the peak discharges for the damaging floods of record were determined at the principal gaging stations within the affected areas on the Trinity River and its tributaries by use of observed and estimated reservoir inflows, streamflow records, and routing procedures. The reductions in peak discharges were determined under two conditions of basin development: (1) Existing conditions resulting from presently existing basin improvements such as diversions, return flows, land treatment, ponds and minor reservoirs, and major existing reservoirs including Navarro Mills Reservoir (under construction) and Bardwell Reservoir (authorized); and (2) 2020 conditions resulting from basin improvements as outlined above, that were assumed would be effective in the year 2020. The existing reservoirs and the reservoirs assumed in operation by the year 2020 are listed in tables 4, 15 and 16 and shown on plate 13.
- 99. Releases from all Corps of Engineers reservoirs in the system, under both existing and 2020 conditions of basin development, were limited, where possible, to such rates as would produce flows not to exceed downstream channel capacities (existing or recommended) on those tributary streams where the reservoirs are located and on the Trinity River between Dallas and the mouth. Operating discharges at key gaging stations under existing and 2020 conditions are shown in the following tabulation:

Streamgaging station	: Existing operating : : discharge (cfs) :	2020 operating discharge (cfs)	
Clear Fork at Fort Worth	6,000	6,000	
West Fork at Grand Prairie	6,000	12,000	
Elm Fork near Carrollton	8,000	12,000 (1)	
Trinity River at Dallas	13,000	20,000	
East Fork near Crandall	2,000	5,000	
Trinity River near Rosser	15,000	25,000	
Trinity River at Romayor	35,000	35,000	

⁽¹⁾ Recommended operating discharge 12,000 cfs. In actual operation releases regulated to 8,000 cfs.

In addition, releases from Lakeview Reservoir on Mountain Creek were limited to 4,000 second-feet or less, releases from Bardwell Reservoir were limited to such rates as would produce flows not to exceed 4,000 second-feet at the mouth of Chambers Creek nor 2,000 second-feet on Waxahachie Creek, and releases from Navarro Mills Reservoir were limited to such rates as would produce flows not to exceed 3,000 second-feet on Richland Creek above the mouth of Chambers Creek.

- 100. The reservoirs in the system, under both existing and 2020 conditions, were regulated insofar as practicable, to maintain approximately the same percentage of flood-control storage utilized in each reservoir. Also, whenever possible, releases were made from one or more of the reservoirs in order to fully utilize the recommended operating discharges shown above.
- 101. Three of the maximum known general floods on the Trinity River Basin, April-July 1942, February-May 1945, and April-July 1957 were routed through the reservoirs under existing and 2020 conditions of basin development following the plan of reservoir regulation set forth in the preceding paragraphs. The reservoir elevations at the beginning of the floods were established by continuous routings for the entire 1924-1957 period. The results of these flood routings are summarized on tables 40, 41, and 42. The reservoir regulations during these flood periods are shown graphically on plates 23 through 37.

TABLE 40 RESULTS OF ROUTING FLOODS OF APRIL-JULY 1942

Reservoir :	Max. res	ervoir	: Peak di	scharge (cfs)
or :	elev. (f	t-msl)	: 1	:Modified	:Modified
stream gage :	Existing:	2020	:Historical	:existing	: 2020
Benbrook	710.0	709.0	_	_	
Fort Worth (Clear Fork)	-	_	18,200	6,100	6,000
Fort Worth (West Fork)	-	_	23,700	16,400	
Grand Prairie	_	_	27,200	15,100	13,700
Lakeview	_	516.9	_	- 1	-
Roanoke	_	609.0	_	_	_
Grapevine	560.0	558.5	_	_	_
Aubrey	-	633.0	_	_	-
Garza-Little Elm	533.6	531.0	• -	-	-
Carrollton	-	-	90,700	24,100	8,000(1)
Dallas	_	-	111,000	53,000	48,000
Lavon	490.0	499.0	<u>-</u>	-	-
Crandall	-		99,200	48,000	37,400
Rosser	- /	-	133,000	93,000	82,300
Bardwell	431.1	429.5	-	-	-
Mouth of Chambers Creek	-	-	39,500	35,700	(2)
Navarro Mills	434.0	432.0	-	-	-
Richland Creek above mo	uth				
of Chambers Creek	-	-	44,800	31,900	(2)
Tennessee Colony	-	274.0	- Contract	_ 4512	representation -
Oakwood	_	-	153,000	+ 93,500	35,000
Riverside	-	-	121,000	74,700	35,000
Romayor	-	-	111,000	69,600	36,500

This routing to 8,000 cfs. Recommended operating discharge subsequently increased to 12,000 cfs.
 In Richland Creek Reservoir.

TABLE 41 RESULTS OF ROUTING FLOODS OF FEBRUARY-MAY 1945

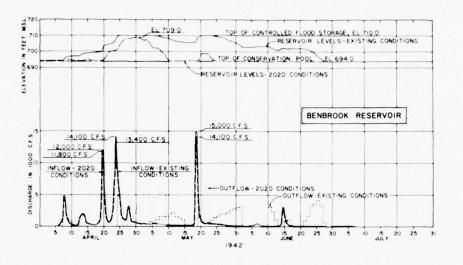
Reservoir		Max. reservoir : Peak discharge (cfs)				
or	: elev. (ft-msl):			:Modified:Modified		
stream gage	:Existing:	2020	:Historical:	existing:	2020	
Benbrook	710.0	704.3				
Fort Worth (Clear Fork)	110.0	104.3	27,000	14,900	13,100	
Fort Worth (West Fork)	기타하다 않는		31,200	15,600	14,900	
Grand Prairie			29,500	17,500	16,800	
	a haidījas.	515.1	29,700	11,000	10,000	
Lakeview Roanoke		601.1				
	555.8	557.2				
Grapevine	222.0	630.0				
Aubrey						
Garza-Little Elm	533.1	527.8	27 000	17 000	9,000(1	
Carrollton	-	-	37,800	11,200	8,000(1	
Dallas	1000	1.05.0	52,900	35,600	26,200	
Lavon	490.0	495.0	() 000	-	-	
Crandall		-	64,000	34,200	5,000	
Rosser		-	66,600	53,200	44,500	
Bardwell	436.0	429.2		-,	,-,	
Mouth of Chambers Creek		-	34,800	31,400	(2)	
Navarro Mills	438.7	435.9		-	- ·	
Richland Creek above mouth						
of Chambers Creek	-	-	62,200	44,300	(2)	
Tennessee Colony	-	281.2		-	-	
Oakwood		-	140,000	123,000	35,000	
Riverside	-	-	116,000	103,800	36,000	
Romayor			106,000	93,000	38,000	
					-	

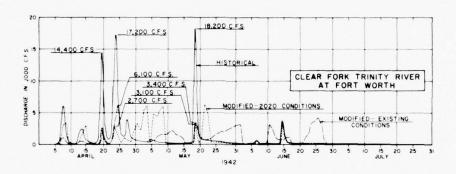
This routing to 8,000 cfs. Recommended operating discharge subsequently increased to 12,000 cfs.
 In Richland Creek Reservoir.

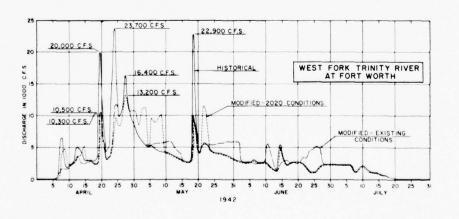
TABLE 42 RESULTS OF ROUTING FLOODS OF APRIL-JULY 1957

Existing: 2020 :reservoirs: (1) : 2020		: Maximum : reservoir		: Peak d	(cfs)	
stream gage : (ft-msl) :exist.CofE:torical :Modifie Benbrook 713.3 702.5 - - Fort Worth (Clear Fork) - - 46,800 14,200 13,900 Fort Worth (West Fork) - - 58,800 26,800 15,100 Grand Prairie - - 68,800 59,200 47,700 Lakeview - 498.6 - - - Roanoke - 595.2 - - - Grapevine 560.8 549.0 - - - Aubrey - 619.0 - - - - Garza-Little Elm 535.6 522.0 -				:Est. peak :		:
Existing: 2020 :reservoirs: (1) : 2020		: elevat	ion			
Benbrook 713.3 702.5 Fort Worth (Clear Fork) 46,800 14,200 13,900 Fort Worth (West Fork) 58,800 26,800 15,100 Grand Prairie 68,800 59,200 47,700 Lakeview - 498.6 68,800 69,200 47,700 Lakeview - 498.6		: (ft-msl)		_:exist.CofE	:torical	:Modified
Fort Worth (Clear Fork) 46,800 14,200 13,900 Fort Worth (West Fork) 58,800 26,800 15,100 Grand Prairie 68,800 59,200 47,700 Lakeview - 498.6		:Existing:	2020	:reservoirs	: (1)	: 2020
Fort Worth (West Fork) 58,800 26,800 15,100 Grand Prairie - 68,800 59,200 47,700 Lakeview - 498.6	Benbrook	713.3	702.5	_		-
Grand Prairie	Fort Worth (Clear Fork)	-	-	46,800	14,200	13,900
Lakeview - 498.6	Fort Worth (West Fork)	_	-	58,800	26,800	15,100
Roanoke - 595.2 - - - Grapevine 560.8 549.0 - - - Aubrey - 619.0 - - - Garza-Little Elm 535.6 522.0 - - - Carrollton - 164,100 13,700 8,400(Dallas - - 222,000 75,300 54,000 Lavon 491.5 496.4 - - - Crandall - - 40,800 33,000 5,000 Rosser - - 142,000 56,000 29,800 Bardwell 431.3 418.0 - - - Mouth of Chambers Creek - - 24,500 22,200 (3) Navarro Mills 443.0 440.7 - - - Richland Creek above mouth of Chambers Creek - - 48,200 31,000 (3) Tennessee Colony - - - - - - Oakwood -	Grand Prairie	-	-	68,800	59,200	47,700
Grapevine 560.8 549.0	Lakeview	-	498.6	-	-	-
Aubrey - 619.0	Roanoke		595.2	-		
Garza-Little Elm 535.6 522.0	Grapevine	560.8	549.0	_		-
Carrollton 164,100 13,700 8,400(Dallas 222,000 75,300 54,000 Lavon 491.5 496.4 Crandall - 40,800 33,000 5,000 Rosser - 142,000 56,000 29,800 Bardwell 431.3 418.0 Mouth of Chambers Creek - 24,500 22,200 (3) Navarro Mills 443.0 440.7 Richland Creek above mouth of Chambers Creek - 48,200 31,000 (3) Tennessee Colony - 262.5 Oakwood - 137,100 81,300 27,300 Riverside - 130,500 91,000 29,300	Aubrey	- 151	619.0	-		-
Dallas 222,000 75,300 54,000 Lavon 491.5 496.4 Crandall - 40,800 33,000 5,000 Rosser - 142,000 56,000 29,800 Bardwell 431.3 418.0 Mouth of Chambers Creek - 24,500 22,200 (3) Navarro Mills 443.0 440.7 Richland Creek above mouth of Chambers Creek - 48,200 31,000 (3) Tennessee Colony - 262.5 Oakwood - 137,100 81,300 27,300 Riverside - 130,500 91,000 29,300	Garza-Little Elm	535.6	522.0	-	-	
Lavon 491.5 496.4	Carrollton	-	-	164,100	13,700	8,400(2)
Crandall - - 40,800 33,000 5,000 Rosser - - 142,000 56,000 29,800 Bardwell 431.3 418.0 - - - - Mouth of Chambers Creek - - 24,500 22,200 (3) Navarro Mills 443.0 440.7 - - - Richland Creek above mouth of Chambers Creek - - 48,200 31,000 (3) Tennessee Colony - 262.5 - - - Oakwood - 137,100 81,300 27,300 Riverside - 130,500 91,000 29,300	Dallas		-	222,000	75,300	54,000
Rosser 142,000 56,000 29,800 Bardwell 431.3 418.0 Mouth of Chambers Creek - 24,500 22,200 (3) Navarro Mills 443.0 440.7 Richland Creek above mouth of Chambers Creek - 48,200 31,000 (3) Tennessee Colony - 262.5 Oakwood - 137,100 81,300 27,300 Riverside - 130,500 91,000 29,300	Lavon	491.5	496.4	•	_	
Bardwell 431.3 418.0 Mouth of Chambers Creek 24,500 22,200 (3) Navarro Mills 443.0 440.7	Crandall	-	-	40,800	33,000	5,000
Mouth of Chambers Creek 24,500 22,200 (3) Navarro Mills 443.0 440.7 Richland Creek above mouth of Chambers Creek 48,200 31,000 (3) Tennessee Colony - 262.5 Oakwood 137,100 81,300 27,300 Riverside - 130,500 91,000 29,300	Rosser	<u>-</u>	-	142,000	56,000	29,800
Navarro Mills 443.0 440.7	Bardwell	431.3	418.0	-		-
Richland Creek above mouth of Chambers Creek 48,200 31,000 (3) Tennessee Colony - 262.5 Oakwood - 137,100 81,300 27,300 Riverside - 130,500 91,000 29,300	Mouth of Chambers Creek	_	-	24,500	22,200	(3)
of Chambers Creek - 48,200 31,000 (3) Tennessee Colony - 262.5 Oakwood - 137,100 81,300 27,300 Riverside - 130,500 91,000 29,300	Navarro Mills	443.0	440.7	-	-	
Tennessee Colony - 262.5 Oakwood - 137,100 81,300 27,300 Riverside - 130,500 91,000 29,300	Richland Creek above mout	h				
Oakwood - 137,100 81,300 27,300 Riverside - 130,500 91,000 29,300	of Chambers Creek		-	48,200	31,000	(3)
Riverside - 130,500 91,000 29,300	Tennessee Colony	4 y 4 -	262.5	<u>-</u>	-	-
	Oakwood		-	137,100	81,300	27,300
Pomeyor _ 125 000 80 000 22 500	Riverside	-	-	130,500	91,000	29,300
12),900 09,000 23,500	Romayor	-	-	125,900	89,000	23,500

Historical or modified existing conditions.
 This routing to 8,000 cfs. Recommended operating discharge subsequently increased to 12,000 cfs.
 In Richland Creek Reservoir.









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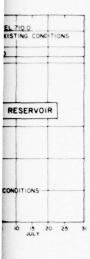
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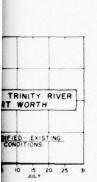
I Historical flow is the streamflow moted to have occurred at a particular conditions existing at the time of the 2 Modified existing contrions, show presently existing watershed improve diversions, return flows, land treatmenter retarding structures, etc. In a ation, Navarro Mills Reservoir funder (authorized) are also assumed to be 3 Modified 2020 conditions, shows shed improvements, including major land treatment, ponds and minor reserve, that are assumed to be effective 4 The existing reservoirs and the reservoir conditions are listed on table Pate 13.

5. Reservoir elevations at the be existing and 2020 conditions are routings.

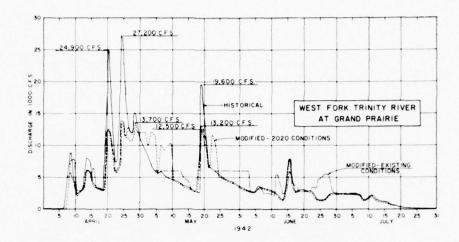
routings
6 The plans of reservoir requirements of watershed developments

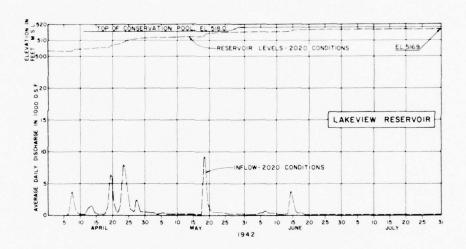
7 Reservoirs, under "modified-exish discharges equal to existing channel under "modified-2020 conditions," operating capacities as shown.











I Historical flow is the streamflow which actually occurred or was estimated to have occurred at a particular point or station under the watershed conditions existing at the time of the flood.

2 Modified existing conditions, shows the hydrographs resulting from presently existing watershed improvements including major reservoirs, diversions, return flows, lond freatment, ponds and minor reservoirs, flood water retarding structures, etc. In addition to reservoirs presently in operation, Novarro Mills Reservoir funder construction) and Bardwell Reservoir (authorized) are also assumed to be existing reservoirs in this study.

3 Modified-2020 conditions, shows the hydrographs resulting from watershed improvements, including major reservoirs, diversions, return flows, land treatment, ponds and minor reservoirs, floodwater retarding structures, etc., that are assumed to be effective in the year 2020 4. The existing reservoirs and the reservoirs assumed operative under

4 The existing reservoirs and the reservoirs assumed operative under 2020 conditions are listed on tables 2, 4, 15 and 16 and shown on Plate 13

5 Reservoir elevations at the beginning of the flood under both existing and 2020 conditions were established by period of record routings.

6 The plans of reservoir regulation under existing and 2020.

6 The plans of reservoir regulation under existing and 2020 conditions of watershed development are summarized in this appendix.

appendix
7. Reservoirs, under "modified-existing conditions," requiated to obtain discharges equal to existing channel capacities (refer to text) and under "modified-2020 conditions," to obtain discharges equal to proposed operating capacities as shown.

GAGING STATION	PROPOSED CHANNEL CAPACITY (C.F.S.)	PROPOSED OPERATING DISCHARGE (C.F.S.)
Clear Fork at Fort Worth	8,000	6,000
West Fork at Fort Worth	15,000	12,000
West Fork at Grand Prairie	15,000	12,000

TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER

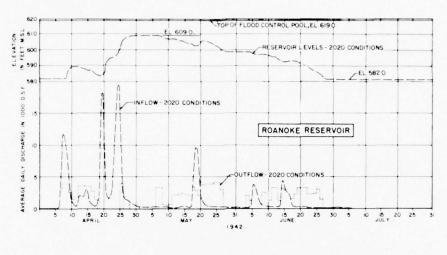
RESERVOIR REGULATION

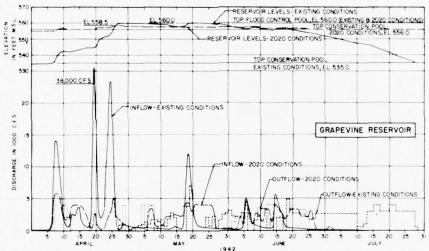
FLOOD OF APRIL - JULY 1942

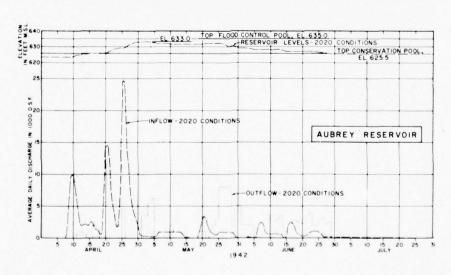
U.S. ARMY ENGINEER DISTRICT, FORT WORTH JUNE 1962

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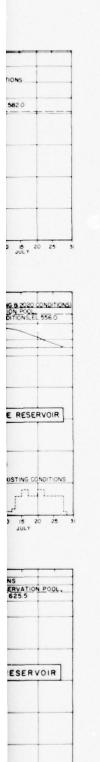
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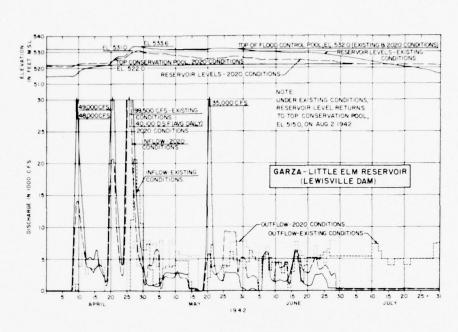
GAGING STATION

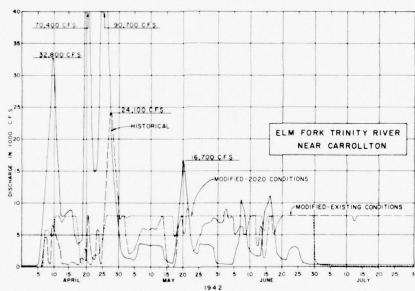
Eim Fork Near Corrollton

* Reservoir regulation here



15 20 25 31 JULY





NOTE

/ See general notes on sheet /

GAGING STATION	PROPOSED CHANNEL CAPACITY (C.F.S.)	PROPOSED OPERATING DISCHARGE (C.F.S.)
Eim Fork Near Carrollton	15,000	12,000 *

Reservoir regulation hereon to 8,000 C.F.S.

TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER

RESERVOIR REGULATION

FLOOD OF APRIL - JULY 1942

IN 5 SHEETS

SCALES AS SHOWN

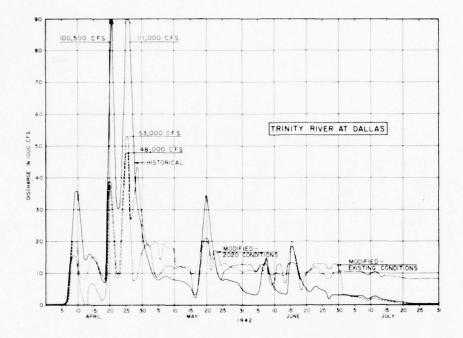
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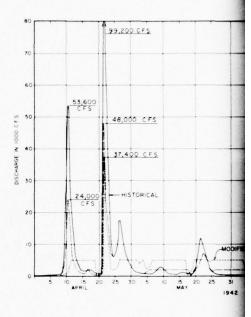
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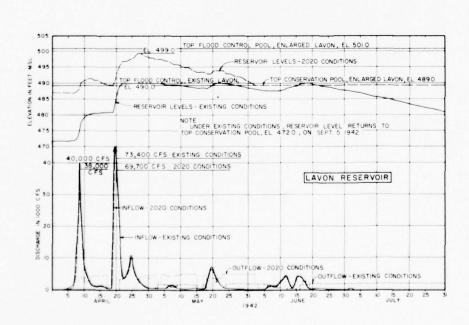
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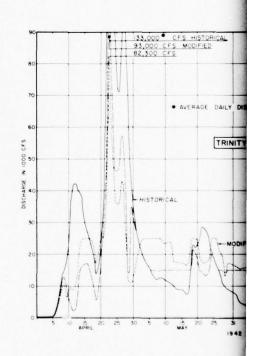
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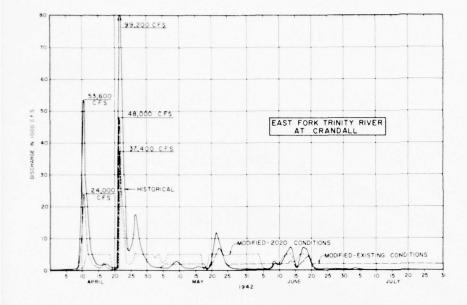
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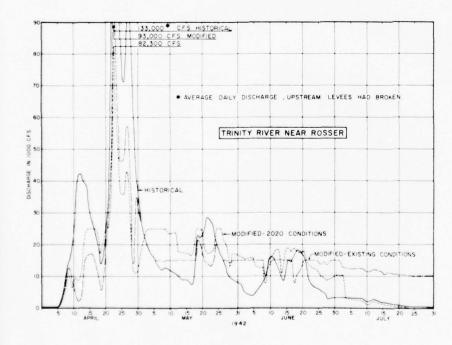






NOTES

1. See general notes on sheet 1.
2 The enlarged Lavon Reservoir, as recommended in report stilled." Review of Reports on Trinty River and Tributaries, Teras, Covering East Fork Watershed," was included in the 2020 system of reservoirs in lieu of the existing Lavon Reservoir



GAGING STATION		PROPOSED OPERATING DISCHARGE (CFS)
Trinity River at Dallas	25,000	20,000
East Fork at Crandall	5,000	5,000
Trinity River nr. Rosser	32,000	25,000

TRINITY RIVER

RESERVOIR REGULATION

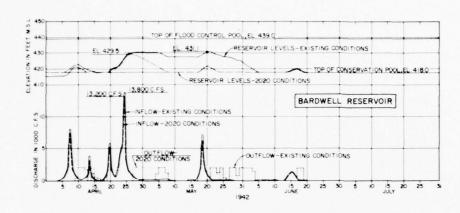
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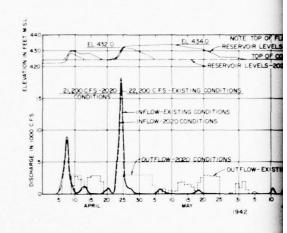
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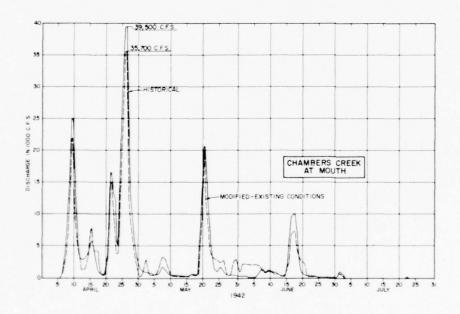
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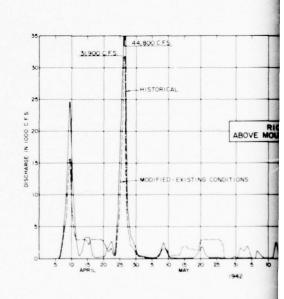
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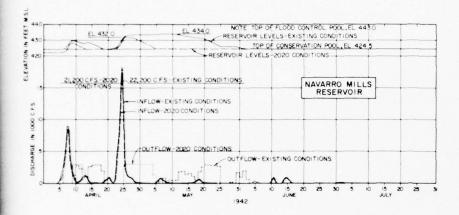
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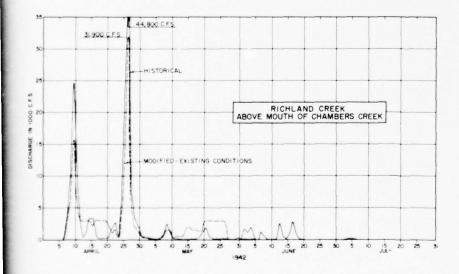












I. See general notes on sheet I. 2. Operating discharges on Chambers Creek at its mouth and on Richland Creek above the mouth of Chambers Creek are 4,000 and 3,000 C.F.S., respectively. Under 2020 conditions, these control points would be inundated by water stored in Richland Creek Reservoir, a proposed local interest reservoir on Richland Creek below the mouth of Chambers Creek 3. Releases from Bardwell and Navarro Mills Reservoirs, under 2020 conditions, were held to a maximum of 2,000 and 3,000 CFS, respectively.

TRINITY RIVER

RESERVOIR REGULATION

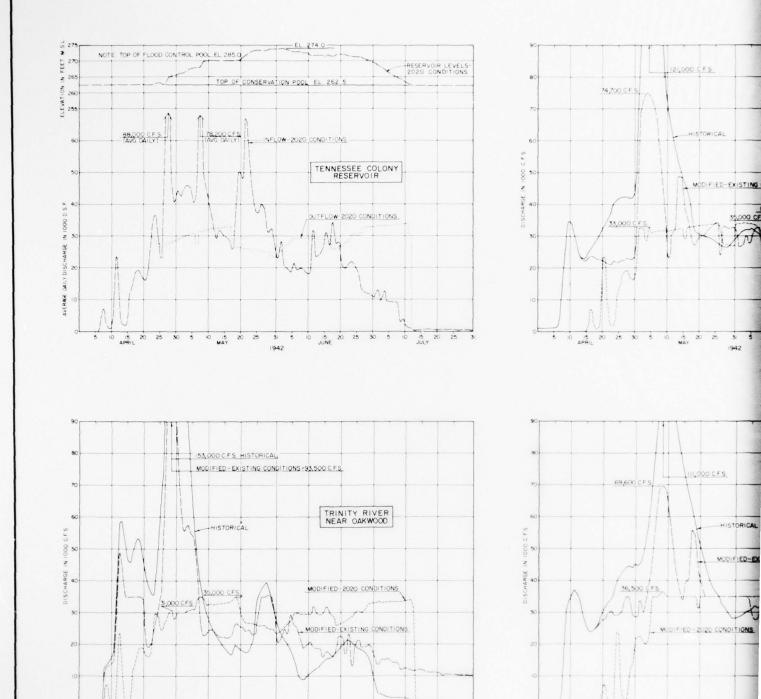
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US ARMY ENGINEER DISTRICT, FORT WORTH

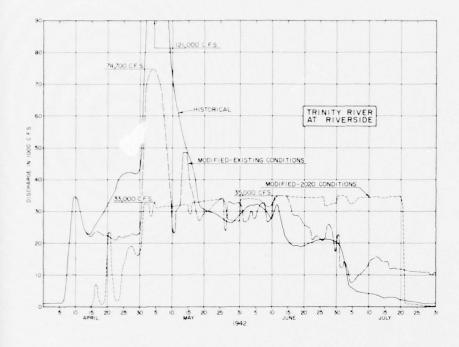
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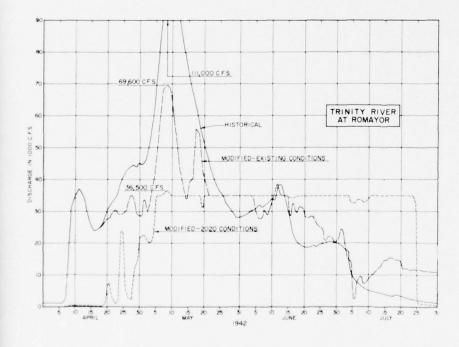
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NOTE See general notes on sheet I

GAGING STATION	PROPOSED CHANNEL CAPACITY (CFS.)	PROPOSED OPERATING DISCHARGE (C.F.S.)
Trinity River near Oakwood	45,000	35,000
Trinity River at Riverside	45,000	35,000
Trinity River at Romayor	45,000	35,000

TRINITY RIVER AND TRIBUTARIES, TEXAS TRINITY RIVER

RESERVOIR REGULATION

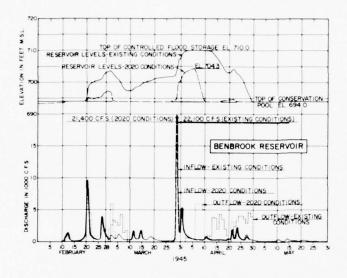
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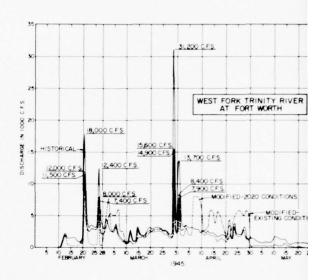
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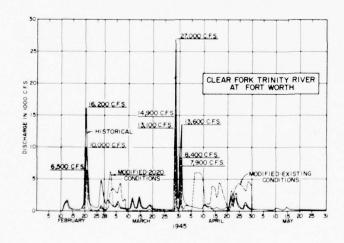
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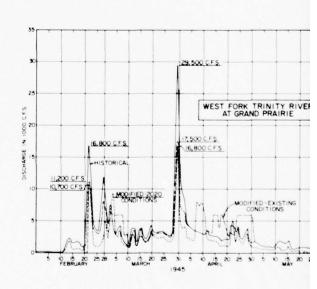
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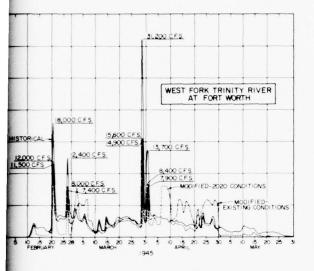
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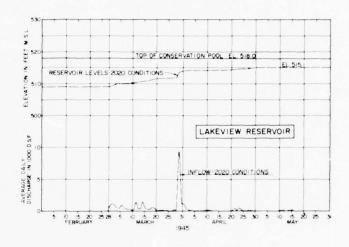












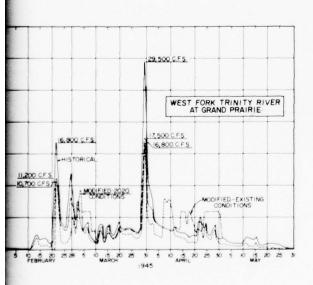


- I. Historical flow is the streamflow which actually occurred or was estimated to have occurred
- at a particular point or station under the watershed conditions austring at the time of the flood.

 2. Modified—existing conditions, shows the hydrographs resulting from presently austring water—shed improvements including major reservoirs, diversions, return flows, land treatment, ponds and minor reservoirs, flood-water retarding structures, etc. In addition to reservoirs presently in operation, Novarro Mills Reservoir (under construction) and Bardwell Reservoir (authorized) are
- also assumed to be existing reservoirs in this study.

 3 Modified-2020 conditions, shows the hydrographs resulting from watershed improvements, including major reservoirs, diversions, return flows, land treatment, ponds and minor reservoirs, floodwater—retording structures, etc.,that are assumed to be effective in the year 2020.
- 4. The existing reservoirs and the reservoirs assumed operative under 2020 conditions are listed on tables 3, 4, 15 and 16, and shown on Plate 13.
- 5 Reservoir elevations at the beginning of the flood under both existing and 2020 conditions were established by period of record routings.
- 6 The plans of reservoir regulation under existing and 2020 conditions of watershed development are summarized in this appendix.
- 7. Reservoirs, under "modified existing conditions," regulated to obtain discharges equal to existing channel capacities (Refer to text...) and under "modified-2020 conditions," to obtain discharges equal to proposed operating capacities as shown.

GAGING STATION	PROPOSED CHANNEL CAPACITY (CFS.)	PROPOSED OPERATING
Clear Fork at Fort Worth	8,000	6,000
West Fork at Fort Worth	15,000	12,000
West Fork at Grand Prairie	15,000	12,000



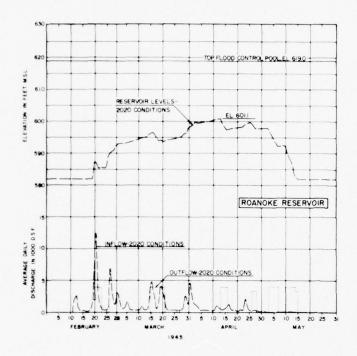
TRINITY RIVER AND TRIBUTARIES, TEXAS TRINITY RIVER

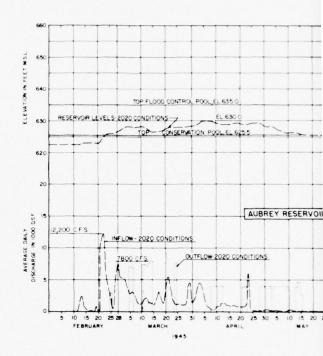
RESERVOIR REGULATION

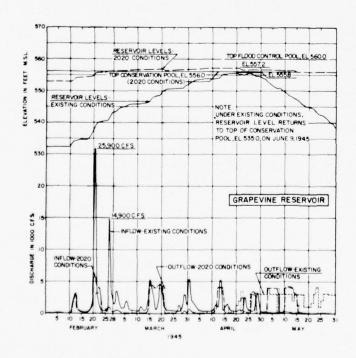
FLOOD OF FEBRUARY - MAY 1945

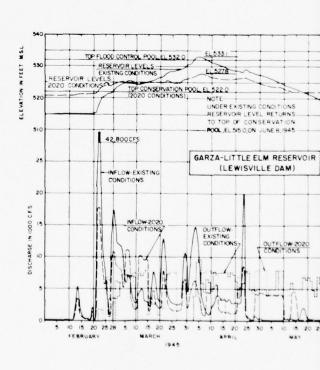
ARMY ENGINEER DISTRICT, FORT WORTH

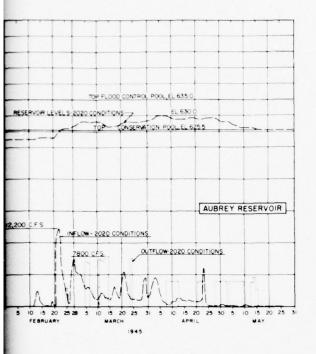
ARMY ENGINEER DISTRICT, FORT W JUNE 1962 norte Muson

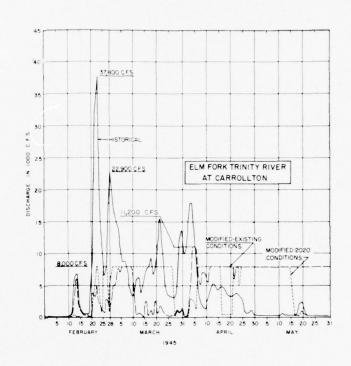


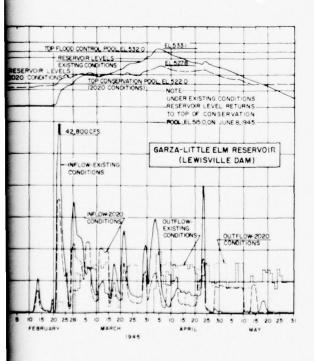












NOTE
See general notes on Sheet I.

GAGING STATION	PROPOSED CHANNEL CAPACITY (CFS)	PROPOSED OPERATING DISCHARGE (CFS)
Elm Fork Nr Carrollton	15,000	12,000*

* Reservoir regulation hereon to 8,000 C F.S.

TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER

RESERVOIR REGULATION

FLOOD OF FEBRUARY MAY 1945

US ARMY ENGINEER DESTRICT, FORT WORTH

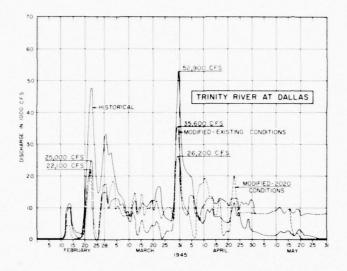
JUNE 1962

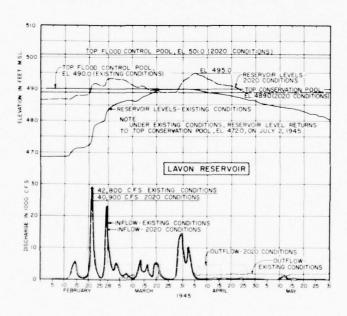
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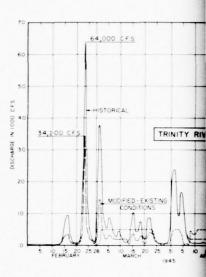
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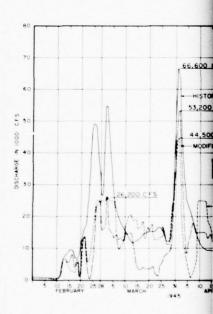
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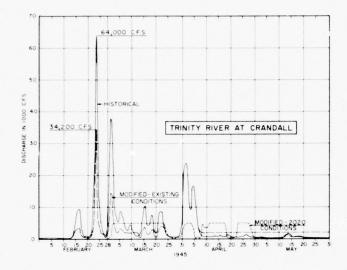
PLATE 29



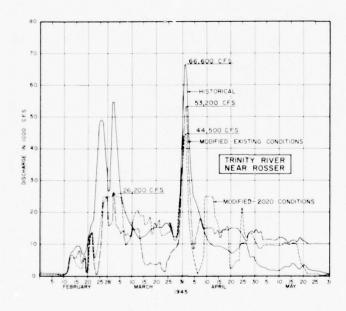








I See general notes on sheet I.
2 The enlarged Lavon Reservoir, as recommended in report titled. "Review of Reports on Trinty River and Tributaries, Texas, Covering East Fork Watershed," was included in the 2020 system of reservoirs in lieu of the existing Lavon Reservoir.



GAGING STATION	PROPOSED CHANNEL CAPACITY (CFS)	PROPOSED OPERATING DISCHARGE (CFS)
Trinity River at Dallas	25,000	20,000
East Fork of Crandall	5,000	5,000
Trinity River nr. Rosser	32,000	25,000

TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER

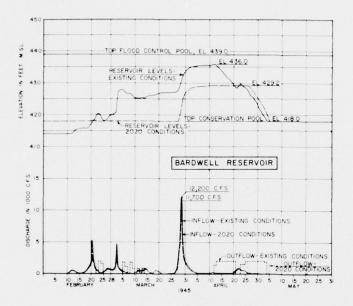
RESERVOIR REGULATION

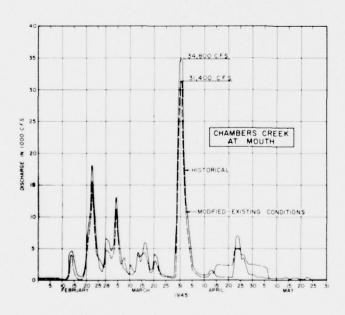
FLOOD OF FEBRUARY-MAY 1945

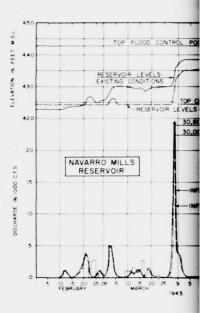
US ARMY ENGINEER DISTRICT, FORT WORTH

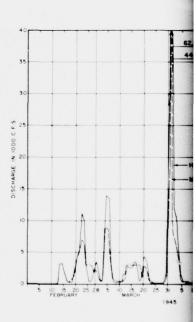
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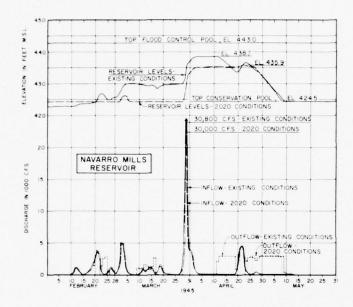
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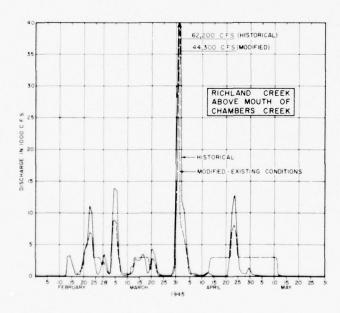












I See general notes on sheet I

I See general notes on sheel I
2 Operating discharges on Chombers Creek at its mouth and on Richland Creek above the mouth of Chambers Creek are 4,000 and 3,000 c.f.s., respectively. Under 2020 conditions, these control points would be inundated by water stored in Richland Creek Reservoir, a proposed local interest reservoir on Richland Creek below the mouth of Chambers Creek Therefore, modified hydrographs are not shown at these points under 2020 conditions. conditions

3 Releases from Bardwell and Navarro Mills
Reservoirs, under 2020 conditions, were held
to a maximum of 2,000 and 3,000 cfs, respectively.

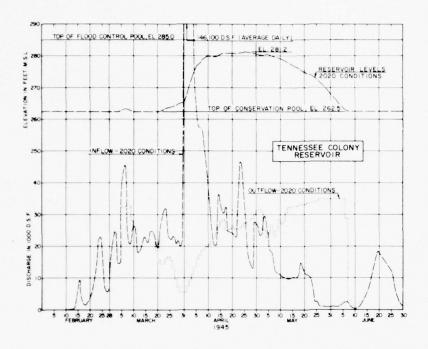
TRINITY RIVER

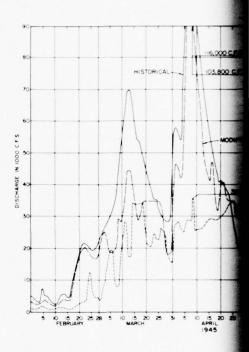
RESERVOIR REGULATION

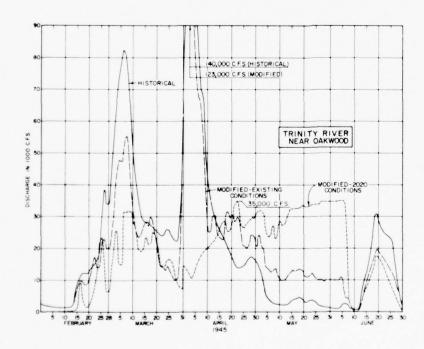
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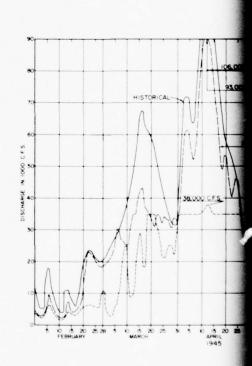
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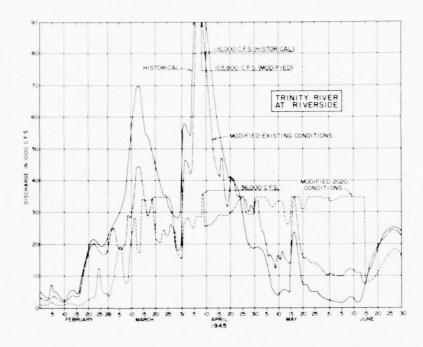
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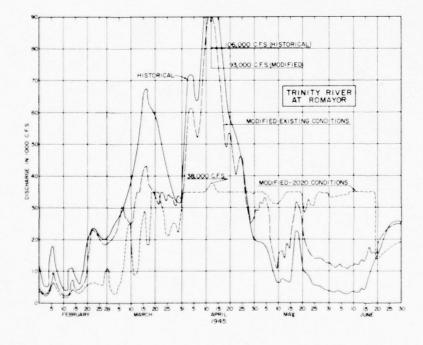












NOTE See general notes on sheet I

GAGING STATION	PROPOSED CHANNEL CAPACITY (C.E.S.)	PROPOSED OPERATING DISCHARGE (C.F.S.)
Trinity River near Oakwood	45,000	35,000
Trinity River at Riverside	45,000	35,000
Trinity River at Romayor	45,000	35,000

TRINITY RIVER AND TRIBUTARIES, TEXAS TRINITY RIVER

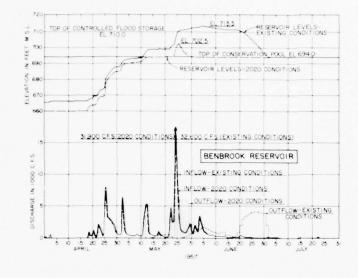
RESERVOIR REGULATION

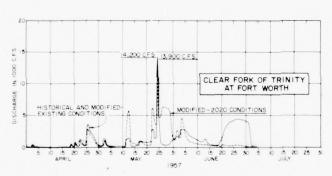
FLOOD OF FEBRUARY-MAY 1945

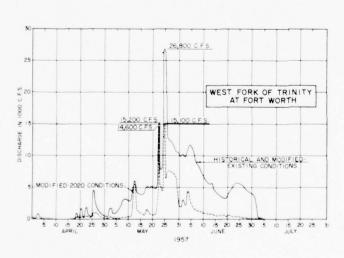
U.S. ARMY ENGINEER DISTRICT, FORT WORTH JUNE 1962

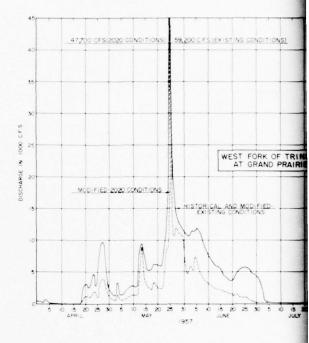
U.S. ARMY ENGINEER DISTRICT, FORT WORTH JUNE 1962

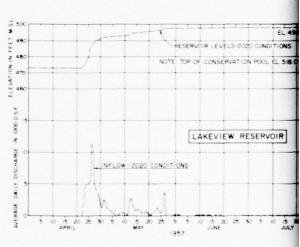
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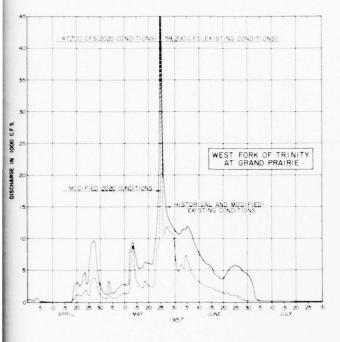


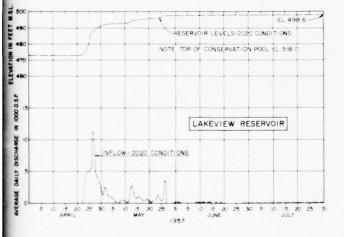












mated to have occurred at a particular point or station under the watershed conditions existing at the time of the flood.

conditions existing at the time of the flood.

2 Modified existing conditions, shows the hydrographs resulting from presently existing watershed improvements including major reservoirs, diversions, (elum flows, land treatment, pands and minor reservoirs, flood water (elanding structures, etc.) in adultion to reservoirs presently in operation, Navarro Milis Reservoir (under construction) and Bardwell Reservoir (under construction) and Bardwell Reservoir (under construction). (authorized) are also assumed to be existing reservoirs in this study.

3 Modified-2020 conditions, shows the hydrographs resulting from water shed improvements, including major reservoirs, diversions, return flows, land treatment, ponds and minor reservoirs, floodwater retarding structures, etc, that are assumed to be effective in the year 2020.

4 The existing reservoirs and the reservoirs assumed operative under

2020 conditions are listed on tables 2,4,15 and 16 and shown of Plate 13

A meserior evacuous under existing conditions are as actually abserved during the 1957 flood period with the exception of Bardwell and Novarro Mills Reservoirs which were started at elevations established by period of record routings. Under 2020 conditions, all reservoir elevations at the beginning of the flood were established by period of record routings 6 The plans of reservoir regulation under existing and 2020 conditions of watershed development are summarized in this appendix

7. The observed peak discharges at stream gaging stations in the Trinity River Basin and the estimated peak discharges that would have occurred if the existing Corps of Engineers' reservoirs had not been in operation are presented in the following tabulation;

	OBSERVED PEAK	ESTIMATED PEAK
LOCATION	DISCHARGE CFS	DISCHARGE CES
Clear Fork at Fort Worth	14, 200	46,800
West Fork at Fort Worth	26, 800	58, 800
West Fork at Grand Prairie	59, 200	68, 800
Elm Fork near Carroliton	13,700	164,100
Trinity River at Dallas	75,300	222,000
East Fork at Crandall	33,000	40,800
Trinity River near Rosser	56,000	142,000
Trinity River near Oakwood	91,800	137,100
Trinity River at Riverside	97, 700	130, 500
Trinity River at Romayor	93,000	125, 900

B. Reservoirs, under "modified-existing conditions," regulated to obtain discharges equal to existing channel capacities (refer to text.) and under "modified-2020 conditions," to obtain discharges equal to proposed operating capacities as shown.

GAGING STATION	PROPOSED CHANNEL CAPACITY CES	PROPOSED OPERATING DISCHARGE CFS
Clear Fork at Fort Worth	· 8,000	6,000
West Fork at Fort Worth	15,000	12,000
West Fork at Grand Prairie	15,000	12,000

TRINITY RIVER AND TRIBUTARIES, TEXAS TRINITY RIVER

RESERVOIR REGULATION

FLOOD OF APRIL - JULY 1957

IN 5 SHEETS

SCALES AS SHOWN

U.S. ARMY ENGINEER DISTRICT, FORT WORTH

JUNE 1962

APPROVAL BY JUNE 1962

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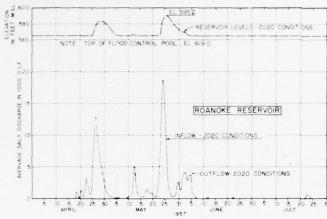
PLATE

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RESERVOIR LEVELS - 2020 CONDITIONS E

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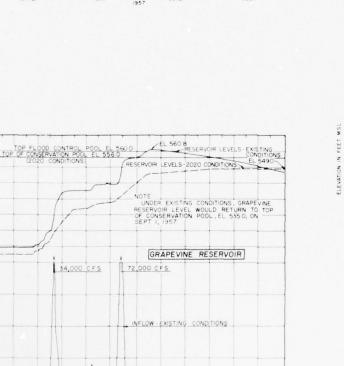
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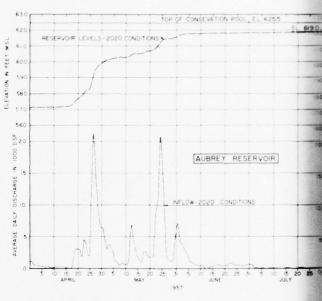
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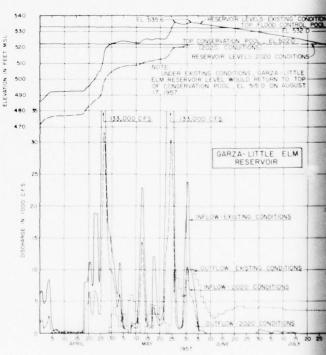
INFLOW - EXISTING CONDITIONS

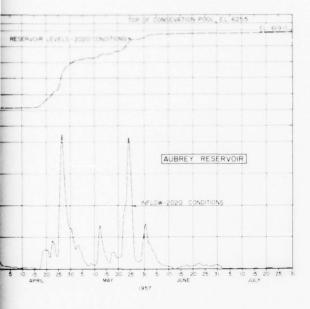
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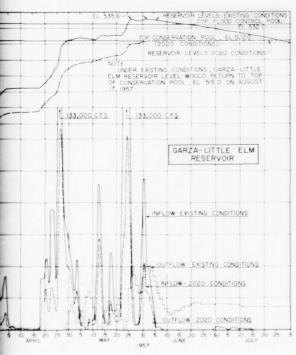
34,000 CFS

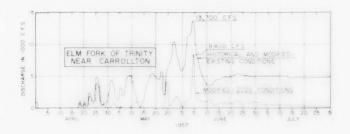












NOTES

I See general notes on Sheet |
2 Garza-Little Elim Reservou operation assumes Gat
Dam breached at the time of the flood under born
existing and 2020 conditions

GAGING STATION	PROPOSED CHANNEL CAPACITY (C.F.S.)	PROPOSED OPERATING DISCHARGE (CF9)
Elm Fork Nr Carrollton	15,000	*000,51

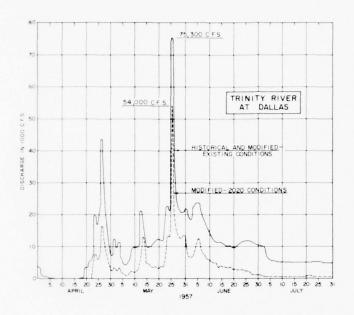
* Reservoir regulation hereon to 8,000 C FS

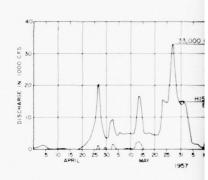
TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER

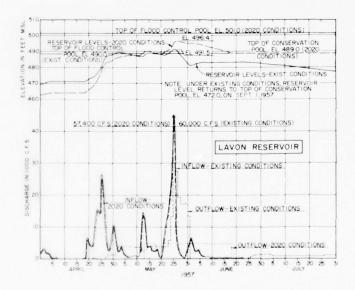
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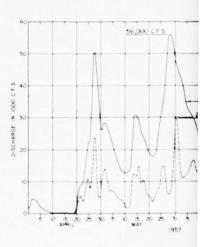
FLOOD OF APRIL - JULY 1957

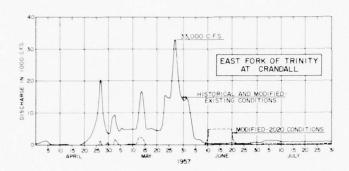
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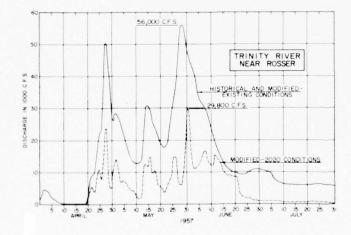




- NOTES:

 I See general notes on sheet I
 2 Under 2020 conditions, releases from Lavan Reservoir are utilized in filling Forney Reservoir and do not oppear at the Crandall gage until Forney Reservoir fills June 9.

 3 The enlarged Lavan Reservoir as recommended in report titled "Review of Reports on Trinity River and Tributaries, Texas, Covering East Fox Watersheet, was included in the 2020 system of reservoirs in lieu of the existing Lavon Reservoir.



GAGING STATION	PROPOSED CHANNEL CAPACITY C.F.S.	PROPOSED OPERATING DISCHARGE C.F.S
Trinity River at Dallas	25,000	20,000
East Fork at Crandall	5,000	5,000
Trinity River near Rosser	32,000	25,000

TRINITY RIVER AND TRIBUTARIES, TEXAS TRINITY RIVER

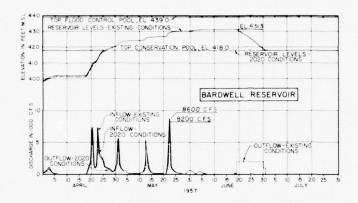
RESERVOIR REGULATION

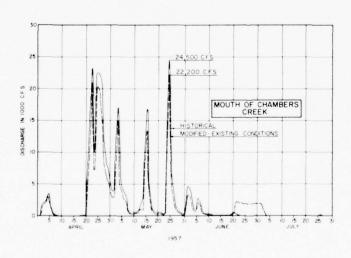
FLOOD OF APRIL - JULY 1957

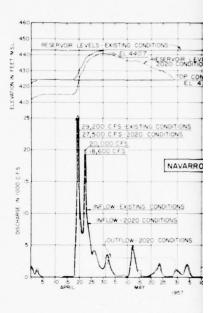
US ARMY ENGINEER DESTRICT, FORT WORTH
SERVICE

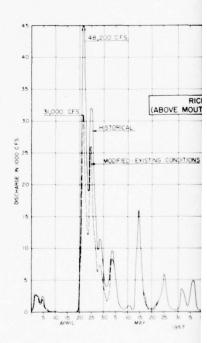
APPROPRIED RECOMMENTED

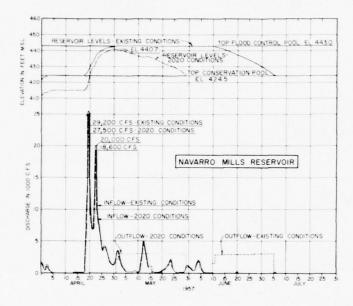
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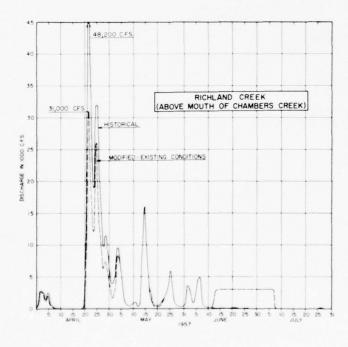












I See general notes on sheet I 2 Operating discharges on Chambers Creek at its mouth and on Richland Creek above the mouth of Chambers Creek are 4,000 and 3,000 c f's respectively Under 2020 conditions, these control points would be inundated by water stored in Richland Creek Reservoir, a proposed local interest reservoir on Richland Creek below the mouth of

points would be inundated by water stored in Richland Creek Reservoir, a proposed local interest reservoir on Richland Creek below the mouth of Chambers Creek Therefore, modified hydrographs are not shown at these points under 2020 conditions 3 Releases from Bardwell and Navarro Milis Reservoirs, under 2020 conditions, were held to a maximum of 2,000 and 3,000 cfs respectively.

TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER

RESERVOIR REGULATION

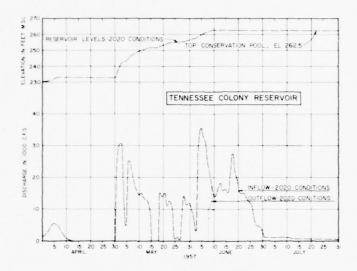
FLOOD OF APRIL - JULY 1957

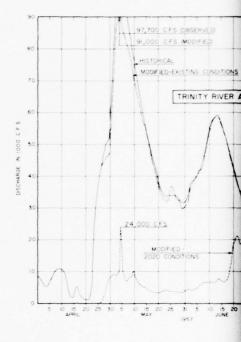
US ARMY ENGINEER DISTRICT, FORT WORTH

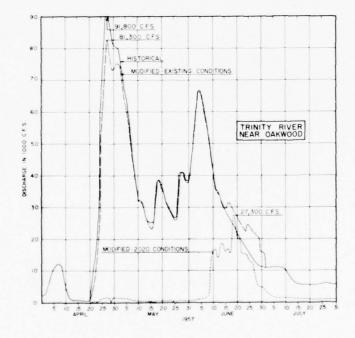
LEAVITY

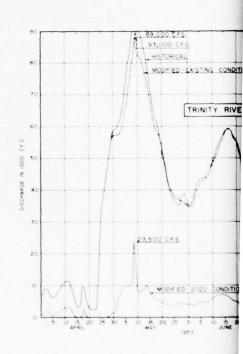
APPROVAL RECEIVED CHEER DISTRICT

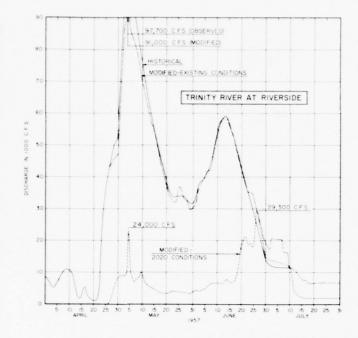
APPROVAL RECEIVED CHEER DI



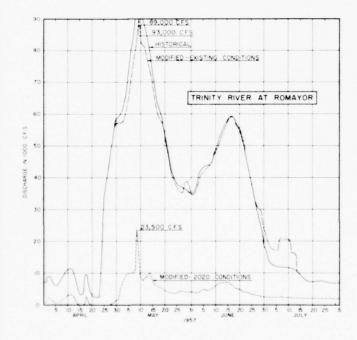








I See general notes on sheet ! 2 Under 2020 conditions, releases from Tennessee Colony Reservoir are utilized in filling Livington Reservoir and do not appear at the



GAGING STATION	PROPOSED CHANNEL CAPACITY (C F S)	PROPOSED OPERATING DISCHARGE (C.F.S.)
Trinity River nr. Oakwood	45,000	35,000
Trinity River at Riverside	45,000	35,000
Trinity River at Romayor	45,000	35,000

TRINITY RIVER AND TRIBUTARIES, TEXAS TRINITY RIVER

RESERVOIR REGULATION FLOOD OF APRIL JULY 1957

102. MINIMUM INFILTRATION INDICES .- Previous studies of initial losses and infiltration indices were made in conjunction with the preparation of definite project reports on Benbrook, Grapevine, Garza-Little Elm (Lewisville Dam), and Lavon Reservoirs, and the Fort Worth and Dallas Floodways; interim reports covering Richland, Chambers, and Cedar Creeks, and Big Fossil Creek; design memoranda covering Bardwell and Navarro Mills Reservoirs; and reviews of reports covering the East Fork and West Fork watersheds. Studies were also made pertaining to the Mountain Creek watershed and the Trinity River Basin above Tennessee Colony Damsite and submitted to the Office, Chief of Engineers with letter SWFGP dated February 17, 1961, subject "Maximum Probable Floods, Proposed Reservoirs, Trinity River Basin, Texas." All such studies were brought up-to-date in accordance with EM 1110-2-1405, "Flood Hydrograph Analyses and Computations." The initial loss and infiltration rate for the area above each of the major upstream projects was based upon the above studies and adopted for use in the determination of spillway design flood hydrographs or design flood hydrographs for the investigated projects. The initial losses and infiltration rates adopted for the major reservoir projects on the Trinity River Basin above the Tennessee Colony Damsite are presented in table 43. Based upon the studies referred to above, and additional studies made in connection with the preparation of definite project reports for projects in the adjacent basins of the Neches Rivers and Buffalo Bayou, an initial loss of 1.0 inch and an infiltration rate of 0.05 inch per hour were adopted for use in the preparation of the spillway design flood hydrograph from the uncontrolled land areas above the Tennessee Colony Damsite.

TABLE 43
MINIMUM INFILTRATION RATES

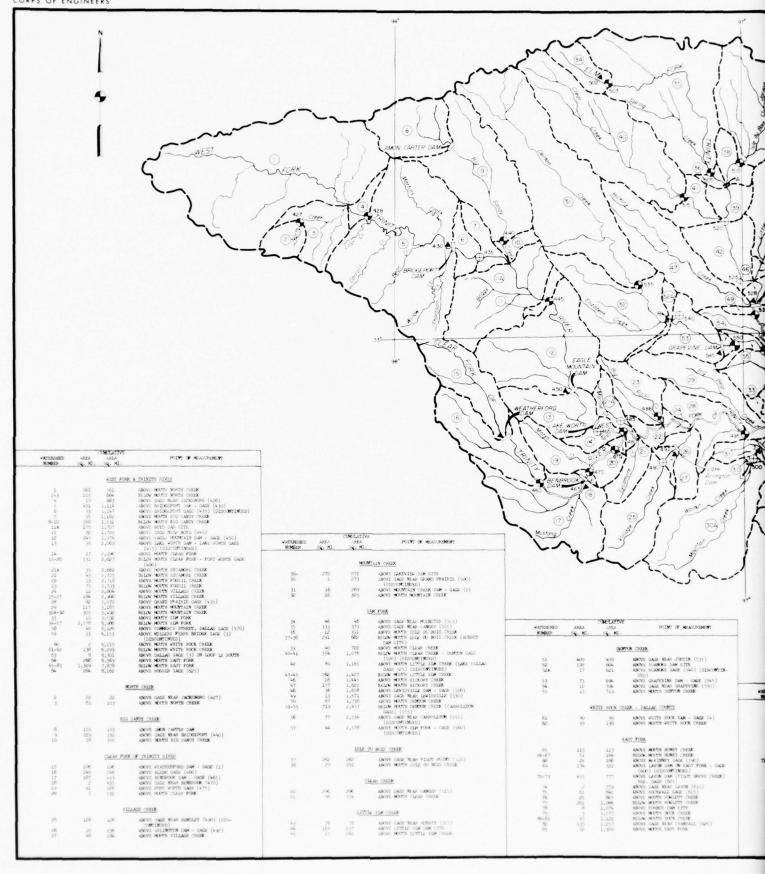
Reservoir or	: Initial loss	:	Infiltration rate	
reservoir site	: (inches)	:	(inch per hour)	
Bridgeport	1.0		0.10	
Eagle Mountain	1.0		0.10	
Benbrook	1.4		0.10	
Lakeview	1.0		0.05	
Roanoke	0.6		0.10	
Grapevine	0.6		0,10	
Aubrey	0.5		0.05	
Garza-Little Elm (Lewisville Da	am) 0.5		0.05	
Lavon	0.5		0.05	
Navarro Mills	1.0		0.05	
Bardwell	1.0		0.05	

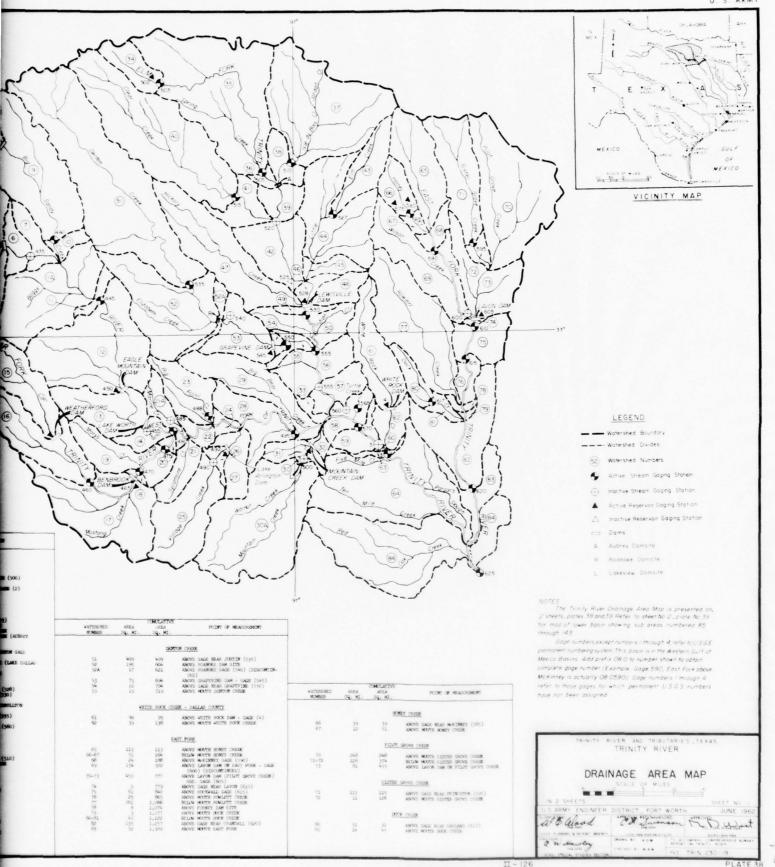
103. UNIT HYDROGRAPH STUDIES AND SYNTHETIC UNIT HYDROGRAPHS.-Unit hydrograph determinations were previously made in conjunction with the preparation of the reports referred to in paragraph 102, above. Also, unit hydrograph studies pertaining to the Mountain Creek watershed were submitted to OCE with letter SWFGP dated November 29, 1960, subject "Unit Hydrograph Compilation, Mountain Creek near Grand Prairie, Texas." All unit hydrograph data were brought up-to-date in accordance with EM 1110-2-1405. Coefficients were adopted for use in Synder's equations for the derivation of 6-hour synthetic unit hydrographs for flow into full reservoir for each of the reservoir projects above Tennessee Colony Damsite in accordance with data presented in previous reports and subsequent studies. These reservoirs control the runoff from a total drainage area of 6,295 square miles. The uncontrolled drainage area of 6,392 square miles above the proposed Tennessee Colony Damsite was divided into 9 land areas and the 195-square mile reservoir area. Table 44 presents the coefficients which were adopted for use in Snyder's equations for the derivation of the synthetic 6-hour unit hydrographs for these 9 land areas. The locations of these areas are shown on the drainage area maps of plates 38 and 39.

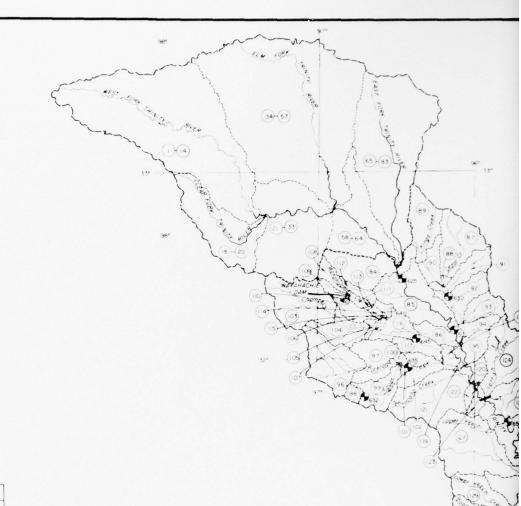
TABLE 44
SYNTHETIC UNIT HYDROGRAPH COEFFICIENTS
FOR UNCONTROLLED AREAS

			E: D. A.
Stream and description of area	: Ct :	Cp640	:(sq.mi.)
West Fork - Reservoirs to mouth of Elm Fork	1.5	500	823
Elm Fork below Reservoirs and Trinity River to mouth of East Fork	1.8	500	715
East Fork - Lavon Dam to mouth	2.0	440	532
Trinity River - Mouth of East Fork to head of Tennessee Colony Reservoir	2.9	460	645
Cedar Creek above head of Tennessee Colony Reservoir	4.5	530	764
Chambers Creek - Bardwell Damsite to head of Tennessee Colony Reservoir	3.0	530	871
Richland Creek - Navarro Mills Damsite to head of Tennessee Colony Reservoir	3.0	530	542
Tehuacana Creek above head of Tennessee Colony Reservoir	3.0	530	248
Small tributary areas and area adjacent to Reservoir (composite)	3.0	530	1,057

The 6-hour synthetic unit hydrographs described above are given in table 45. Additional synthetic unit hydrographs were developed for incremental areas other than those given in table 45 for use in connection with standard project flood hydrographs for the design of floodways. The 6-hour unit hydrographs for the uncontrolled area of the Elm Fork and the incremental areas on the Trinity River from the confluence of the West and Elm Forks to below the mouth of White Rock Creek are given in table 46. The synthetic 1-hour unit hydrographs used in computing standard project floods on Duck Creek are also given in table 46.



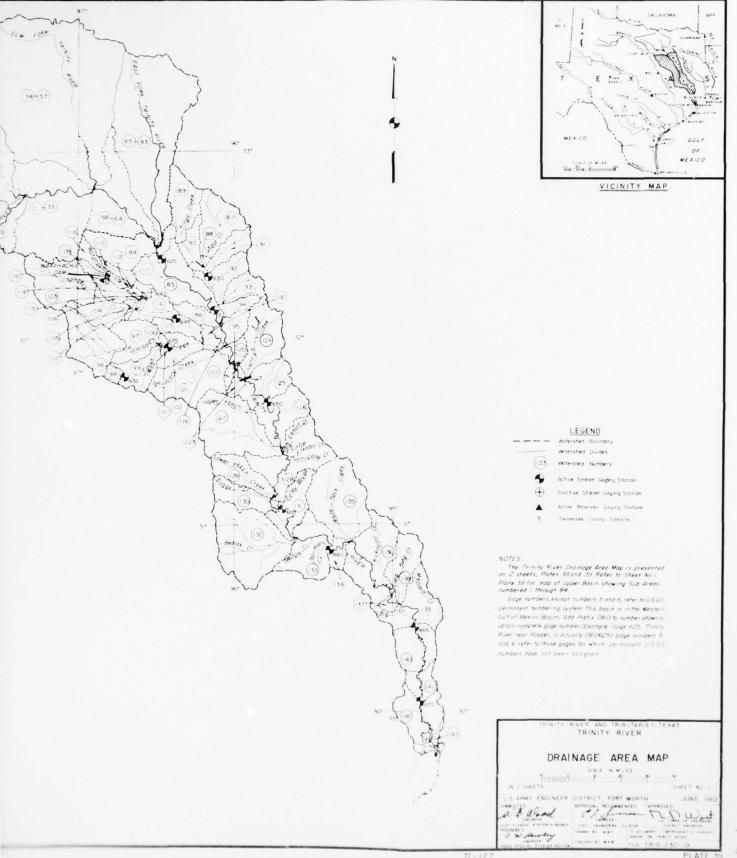




WATERSHIP	AREA	CUMULATIVE AREA		POINT OF MEASUREMENT
 NUMBER	SQ. HI.	SQ. MI.		POINT OF MEADUREMENT
	WEST P	ORK & TRINIT	REVIE Y	
1-14	2,096	2,096	ABOVE	MOUTH OF CLEAR FORK
15-20	531	2,627	BELOW	MOUTH OF CLEAR FORK
21A-33	875	3,502		MOUTH OF ELM FORK
34-57	2,578	6,080		MOUTH OF ELM FORK
58-64	489	6,569		MOUTH OF EAST FORK
65-83	1,309	7,878		MOUTH OF EAST FORK
84	264	8,162	ABOVE	ROBSER GAGE (625)
		TRINITY RIVE	2	
85	404	8,566	ABOVE	TRINIDAD GAGE (5)
86	99	8,665		MOUTH CEDAR CREEK
87-94	1,072	9+737		MOUTH CEDAR CREEK
95	111	9,848		MONTH RICHLAND CREEK
96-119	1,990	11,636		MOUTH RICHLAND CREEK
120	65	11,903		HOUTH TEHUNCANA CHEEK
151	377	12,280		PALESTINE DAM SITE
122	35	12, 135	LOW	MORTH THE ACANA CREEK

84	284	8,162	ABOVE ROBSER GAGE (625)
	204	0,100	ADOVE ROBBER UNDE (UZ))
		TRINITY RIVER	
85	404	8,566	ABOVE TRINIDAD GAGE (5)
86	99	0,665	ABOVE MOUTH CEDAR CREEK
87-94	1,072	9,737	BELOW MOUTH CEDAR CREEK
95	111	9,848	ABOVE MONTH RICHLAND CREEK
96-119	1,990	11,636	BELOW MOUTH RICHLAND CREEK
120	65	11,907	NOVE HOUTH TEHUNCANA CREEK
121	377	12,280	POWE PALESTINE DAM SITE
122	35	12,135	LOW MONTH TYPE ACANA CREEK
123	47	12,382	ABOVE MONTH CATPIER CREEK
124	305	12,687	BELOW MOUTH CATFISH CREEK (TENN. COLONY DAW SITE)
125		12,512	ABOVE GAKWOOD GAGE (650)
126	256	13,166	ABOVE MONTH PPER KEECRI CHEEK
127	912	13,680	BELOW MONTH UPPER KEECHI CREEK
128	1629	14,100	ANOVE MONTH LOWER KEECHI CREEK
129	199	14,301	BELOW MOUTH LOWER KEECHI CREEK
130	18%	14,484	ABOVE MIDWAY GAGE (655)
132		14,696	ABOVE MOUTH BEDIAS CREEK
132	503	15,290	BELOW MOUTH BEDIAS CREEK
133	320	15,519	ABOVE RIVERBIDE GAGE (660)
134	60	15,688	ABOVE HOUTH WHITE HOCK CREEK
135	518	16,206	BELOW MOUTH WHITE ROCK CHEEK
136	NOO.	16,606	ABOVE LIVINGSTON DAM SITE
137	67	16,673	ABOVE MOUTH LONG KING CREEK
136	214	16,887	BELOW MONTH LONG KING CREEK
139	305	17,192	LEGYE HOMAYOR GAGE (665)
140	594	17,436	ABOVE CAPERS RIDGE DAM SITE (LIMERTY)
191	10%	17,539	ABOVE LIBERTY GAGE (670)
142		17,760	ABOVE WALLISVILLE DAM SITE
143	85	17,845	ABOVE MOUTH THINTTY RIVER
		CEDAP CHEEK	
87	267	267	ABOVE CEDAR DAM SITE
88		277	ABOVE MOUTH KINGS CHEEK
894(8)	336	611	BELOW MOUTH KINGS CREEK
		739	ABOVE GAGE NEAR MARANK (630)
(2)	190	0.4	ABOVE MONTH CLEAR CREEK
93	119	1,013	BELOW MOOTH CLEAR CREEK - CEDAR CHEEK DAM SITE (NON-FEDERAL)
34	39	1,000	ABOVE MOUTH CEDAN CREEK
		KING CROK	
89	230	7.98	ABOVE SCHREY DAM SITE ABOVE MORTH KIRKS CHEEK

WATERSHED MILMOREN	AREA SQ. MI.	CUMULATIVE AREA SQ. MI.	POINT OF MEASUREMENT
		RICHLAND	CREDX
96	316	316	ABOVE NAVAPRO MILLS DAM
97	218	534	ABOVE MOUTH PINOAK CREEK
98-99	179	713	BELOW MOUTH PINOAK CREEK
100	1	714	ABOVE RICHLAND DAM SITE
101	23	737	ABOVE GAGE NEAR RICHLAND (635)
102	129	866	ABOVE MOUTH CHAMBERS CREEK
103-117	1,072	1,938	BELOW MOUTH CHAMBERS CREEK
118	40	1,978	ABOVE RICHLAND CREEK DAM SITE (PROPOSE NON-PEDERAL)
119	12	1,990	ABOVE MOUTH RICHLAND CROSK
		PINOAK C	REDX
96	18	18	ABOVE GAGE NEAR HUBBARD (632)
99	161	179	ABOVE MOUTH PINOAK CREEK
		CHAMBERS	CREEK
103	372	372	ABOVE ITALY DAM SITE
104	160	532	ABOVE RANKIN DAM SITE
105	26	558	ABOVE MOUTH BIG ONION CREEK
106	73	631	BELOW MOUTH BIG ONION CREEK
107	- 4	635	ABOVE MOUTH WAXAHACHIE CREEK
108-114	187	822	BELOW MOUTH WAXAHACHIE CREEK - EMHANSE GAGE (640) (DISCONTINUED)
115	15	837	ABOVE EMHOUSE DAM SITE
116	134	971	ABOVE GAGE NEAR CONSIDANA (645)
117	101	1,072	ABOVE MOUTH CHAMBERS CREEK
		WAXAHATRIE	CHIEK
106	66	66	ABOVE MOCTH SOUTH PHONG CREEK
109-110	. 32	96	BELOW MOUTH SOUTH PRONG CREEK
111	24	122	ABOVE MONTH MISTANG CHEEK
112	- 16	168	BELGW MOUTH MESTANG CREEK
113		171	ABOVE BARDWELL DAM SITE
114	16	187	ABOVE MOSTH WAXABACRIE CHEEK
		SOUTH PROD	C CREEK
			Language Committee and Committee Com
109 110	31	31 10	AMOVE WASABACHIE DAM - GADE (6) AMOVE MOSTE DOUTT PROME CREEK



	(SECOND-FEET)
	DAMSITE
	COLONY
	TENNESSEE
	ABOVE
	AREAS*
	CAND
-	SUBWATERSHED
	COMPONENT
	FOR
	HYDROGRAPHS
	TIME
	6-HOUR
	THERETC

Small tributery erees, eres adjacent to Reservoir, and Reservoir surface eres D. A. e. 1,5% sq. mi.	######################################
Tehimeens Creek - Aree above beed of Tempesee Colony Reservoir Tempesee Colony Reservoir D. A SkS sq. mt.	98888888888888888888888888888888888888
idehland Creek - Maranto Mills Paratte to beed of Toinesees Colony Reservoir D. A Ske sq. ml.	\$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$
Chambers Creek - Parlwell Darsite to bead of Tennessee Colony Reservoir D. A BYL sq. ml.	7746499649888888888888888888888888888888
Geder Creek - Area above head of Tennessee Colony Reservoir T. A 376 aq. ml.	\$25588888888888888888888888888888888888
Trintty River - mouth of Mat Pork to head of Tennessee Colony Reservoir D. A. = 645 sq. ml.	80
ther Fork Trinity for Trinity for month to mouth to mouth to mouth for mouth for mouth the factor of the form of t	800 8.00 8.00 8.00 8.00 8.00 8.00 8.00
Elm Fork below Reservoirs and Trinkty River to mouth of East Form O. A. = 715 sq. ml.	\$\\ \&\\ \&\\ \&\\ \&\\ \&\\ \&\\ \&\\
West Fork - Meservolrs to mouth of Elm Fork Thinky Miver To A. = 823 sq. ml.	### C
Hehland Greek - Area above Mwarro Mills Demafte D. A. = 316 sq. mt.	8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8
Chembers Creek - Area shove Berdvell Demsite I. A. a. TT sq. mi.	\$6.688 \$6.888 \$6
Fast Pork - Area above -levon Dam - A. G	다 10 - 10 - 10 - 10 - 10 - 10 - 10 - 10
ELM FORK - A Aubrey Dameite to Lewisville Dam D. A. = 976 sq. mi.	######################################
ELm Fork above Aubrey Damsite In A. = 583 eq. ml.	869 9 9 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8
Denton Greek - Roanoke Damaite to Grapevine Dam D. A. = 90 sq. mi.	तेष्वेते
Denton Creek Above Boanoke Damaite D. A. = 60% eq. mi.	edizini
- Meantain Oreek - Area mbove Lakeview Dumnite .h. A. d Tr A. d	888851445 888851445 888851445 888884445 888884445 888884445 888884445 888884445 888884445 888884445 888884445 888884445 888884445 888884445 888884445 888884445 888884445 888884445 888884445 888884445 88888445 88888445 8888845 8888845 8888845 8888845 8888845 888885 888885 888885 888885 888885 888885 888885 888885 888885 888885 888885 888885 888885 888885 888885 888885 888885 88885 888885 888885 888885 888885 888885 888885 888885 888885 888885 888885 888885 888885 888885 888885 888885 888885 888885 8885 8895 885 88
Mest Form to Bridgeport Dun to Maje Mountain Den D. A. = 860 pq. md.	8 2228538833555448888888888888888888888888
Ment Fork . Area above Bridgeport Dan G. A Lille aq. mt.	췙즫쭃찞윭즼읡튽윉윉잗됮뢵밁묫윉뀰믮잗긝첀 퓩잗껿텇캮귳둮믮쳶쳶캮굺츱뼥뼥잗퓩궦찞퓩궦ন
Clear Fore - Aree above Senbrees pan A. A 433 sq. mt.	85555555555555555555555555555555555555
V Dough	· · · · · · · · · · · · · · · · · · ·

TABLE 46
SYNTHETIC 6-HOUR UNIT HYDROGRAPHS - ELM FORK & TRINITY RIVER
AND 1-HOUR UNIT HYDROGRAPHS - DUCK CREEK (SECOND-FEET)

Duck Creek at lower end of improvement	
Duck Creek : at head of : improvement : D.A. = 9.4 sq.mi.:D	1,240 3,180 3,180 1,550 1,550 510 370 100 100
1/2 : hour : periods :D	1 2 8 4 5 0 C 8 6 0 C C C C C C C C C C C C C C C C C C
: Trinity River :Dellas Gage to : mouth of White : Rock Greek :D.A. = 173 sq.mi.	1,100 6,750 6,670 1,020 1,020 1,020 1,020 1,020 1,000 600 600 600 1,000 1,000 1,000 600 1,000
: Trinity River : mouth of Elm : Fork to : Dallas Gage :D.A. = 40 sq.mi.	3,740 2,100 1,060 1,060 4,50 260 1,50 80 30 10 0
: Uncontrolled : area above : mouth of : Elm Fork : D.A. = 226 sq.mi.	980 11,890 9,310 6,220 3,510 1,450 1,120 800 680 680 680 110 240 240 240 240 240 240 240 240 240 24
3-hour periods	10 8 4 5 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

104. SPILLWAY DESIGN STORMS. - The spillway design floods previously presented in definite project reports for Benbrook, Garza-Little Elm, Grapevine, and Lavon Reservoirs were based on probable maximum storm rainfall values determined by the Hydrometeorological Section of the United States Weather Bureau and furnished this office by OCE letter SPEWE dated February 11, 1946, subject "Preliminary Estimates of Maximum Possible Storm Precipitation for the Upper Trinity River, Texas." A summary of these spillway design storm data is given in the following tabulation:

	:Duration:	Rainfal	l(inches):Ra	infall-e	
Reservoir	of storm: :(hours):	Total	:Maximum: :6-hours:	Total	: Maximum : 6-hours
Benbrook	60	28.2	15.6	21.5	14.7
Garza-Little Elm (Lewisville Dam)	60	23.2	11.0	20.3	10.7
Grapevine	60	26.5	14.1	21.5	13.5
Lavon	60	26.2	13.7	23.3	13.4

105. The spillway design storms adopted in the present report for use in the design of spillways at Lakeview, Aubrey, and Roanoke Reservoirs, and for testing the existing spillways at Garza-Little Elm and Grapevine Reservoirs were computed following a method described in the U.S. Weather Bureau Hydrometeorological Report No. 33, dated April 1956, subject "Seasonal Variations of the Probable Maximum Precipitation East of the 105th Meridian for Areas From 10 to 1,000 Square Miles and Durations of 6, 12, 24, and 48 Hours." Computations of basin shape factors for each reservoir were analyzed. As a result of these studies a basin shape reduction factor of ten percent was used for all 5 reservoir projects. Two storm patterns were considered for Garza-Little Elm Reservoir. One pattern assumed the storm centered over the total area above the Garza-Little Elm Reservoir and the other assumed the storm centered on the local area between Aubrey and Garza-Little Elm Reservoirs. Two storm patterns were likewise considered for Grapevine Reservoir - one with the storm centered on the total area and the other with the storm centered on the area between Roanoke and Grapevine Reservoirs. Routings of hydrographs resulting from these storm patterns through the recommended reservoirs, indicated that at both Garza-Little Elm and Grapevine Reservoirs the storm centered over the local area was more critical and was adopted for the spillway design storm. Based on the above criteria, the total rainfall for the design storms for these projects was as follows: Lakeview, 31.32 inches; Aubrey, 28.55 inches; Roanoke, 28.88 inches; Garza-Little Elm, 26.33 inches (27.45 inches over the area between Lewisville Dam and Aubrey Damsite and 24.71 inches above Aubrey Damsite); and Grapevine, 28.55 inches (33.82 inches over the area between Grapevine Dam and Roanoke Damsite, and 27.77 inches above Roanoke Damsite).

106. The spillway design storm rainfall for Tennessee Colony Reservoir is based on the curves furnished with letter SWFGP dated February 17, 1961, subject "Maximum Probable Floods, Proposed Reservoirs, Trinity River Basin, Texas," and recommended changes in indorsements thereto as approved by OCE. The storm duration of 48-hours indicated on the referenced curves was considered inadequate for the drainage area above Tennessee Colony Damsite. Therefore, the duration of the spillway design storm was increased to 108 hours, based on the areadepth-duration curves of the June 27-July 1, 1899 storm prepared in connection with storm study GM 3-4. Transposition of the 1899 storm over the basin above Tennessee Colony Damsite produced a basin shape factor of 93 percent. With the storm centered over the uncontrolled area below the upper Trinity River reservoirs, and the total rainfall determined as outlined above, the average depth of rainfall over the 6,392 square miles of uncontrolled drainage area was 25.13 inches. The rainfall, loss, and rainfall-excess for the spillway design storms described in the preceding paragraphs are given in tables 47 and 48.

TABLE 47
SPILLWAY DESIGN STORM RAINFALL AND RAINFALL-EXCESS

	ove	storm cer er total Lakeview	area	Design store over to above Ros	total a	rea	: ove	storm c er total Grapevin	area
6- :	Area above	e Lakevie	w Damsite	Area above	Roanok	e Damsite	: Area abo	ve Grape	vine Dem
period	6-hour increment of rainfall (inches)		: :Rainfall- : excess):(inches)	of rainfall:	Loss (inches	: :Rainfall- : excess):(inches)			: Rainfall: excess :(inches)
1	0.92	0.92	0.00	0.84	0.60	0.24	0.92	0.60	0.32
2	0.97	0.38	0.59	0.99	0.60	0.39	0.99	0.60	0.39
3	1.11	0.30	0.81	1.13	0.60	0.53	1.17	0.60	0.57
4	1.30	0.30	1.00	1.43	0.60	0.83	1.42	0.60	0.82
5	1.59	0.30	1.29	2.32	0.60	1.72	2.17	0.60	1.57
6	4.72	0.30	4.42	15.87	0.60	15.27	15.43	0.60	14.83
7	18.58	0.30	18.28	4.58	0.60	3.98	4.72	0.60	4.12
8	2.13	0.30	1.83	1.72	0.60	1.12	1.73	0.60	1.13
Total	31.32	3.10	28.22	28.88	4.80	24.08	28.55	4.80	23.75

6- :				Roanoke Damsi Area between		evine Dam	: over : above A	total ar ubrey Da	msite
hour : eriod:	Area above 6-hour : increment : of rainfall: (inches) :	Loss	: :Rainfall-	and Roar 6-hour increment of rainfall: (inches):	Loss	msite : :Rainfall- : excess	of rainfall	: : Loss	: Rainfall: excess
1	0.93	0.60	0.33	0.88	0.60	0.28	0.92	0.50	0.42
2	1.00	0.60	0.40	0.94	0.60	0.34	0.99	0.30	0.69
3	1.19	0.60	0.59	1.04	0.60	0.44	1.17	0.30	0.87
14	1.47	0.60	0.87	1.10	0.60	0.50	1.37	0.30	1.07
5	2.25	0.60	1.65	1.67	0.60	1.07	2.30	0.30	2.00
6	14.49	0.60	13.89	21.69	0.60	21.09	4.72	0.30	4.42
7	4.67	0.60	4.07	5.08	0.60	4.48	15.48	0.30	15.18
8	1.77	0.60	1.17	1.42	0.60	0.82	1.60	0.30	1.30
otal	27.77	4.80	22.97	33.82	4.80	29.02	28.55	2.60	25.95

	over t	storm cotal are	ea		Lewis	over ar	orm centered eabetween nd Aubrey Da	msite	
	: Area above	Lewisvi	lle Dam	Area above	Aubrey	Damsite	: Area between and Aub	en Lewis rey Dams	
	6-hour increment of rainfall: (inches):			: 6-hour : : increment: : of rainfall: : (inches) :			: 6-hour : increment :of rainfall : (inches)	: Loss	: :Rainfall- : excess):(inches)
1	0.95	0.50	0.45	1.00	0.50	0.50	0.90	0.50	0.40
2	1.12	0.30	0.82	1.25	0.30	0.95	1.03	0.30	0.73
3	1.17	0.30	0.87	1.25	0.30	0.95	1.13	0.30	0.83
14	1.44	0.30	1.14	1.59	0.30	1.29	1.33	0.30	1.03
5	2.97	0.30	2.67	3.48	0.30	3.18	2.50	0.30	2.20
6	4.05	0.30	3.75	3.64	0.30	3.34	4.45	0.30	4.15
7	12.78	0.30	12.48	10.49	0.30	10.19	14.38	0.30	14.08
8	1.85	0.30	1.55	2.01	0.30	1.71	1.73	0.30	1.43
Total	26.33	2.60	23.73	24.71	2.60	22.11	27.45	2.60	24.85

SPILLMAY DESIGN STORM RAINFALL AND RAINFALL-EXCESS
TENNESSEE COLOGNY RESERVOLM TARLE 48

th of	Red nfell- excess (inches)		00	0	0	0.30	69.0	0.68	0.13	1.01	1.09	200	9	0.30	70.0	0	0	0	12.19	200 an mi	as, Area	De la Cart	excess inches)	0	0	0 0	0 83	1.01	1.06	1.14	100	69.9	5.06	0.51	0.18	g	
West Fork Trinity River- Reservoirs to mouth of	Loss nches)		0.10	0.13	0.17	64.0	0.30	0.30	0.30	0.30	2000	200	0.30	0.30	0.30	0.23	0.11	0.11	4.45	200	Tributary Areas, Are mt to Reservoir and	1	Loss excess (inches):(inches	0.14	0.15	0.20	0.30	0.30	0.30	0.30	00.00	0.30	0.30	0.30	0.30	0.15	2000
Reservoi	Average : rainfall: (inches):(3		0.10	0.13	0.17	0.81	0.93	86.0	1.03	7.5	67.4	209	080	09.0	0.34	0.23	0.11	0.11	16.64		Small Trib adjacent to Reservoir	The state of the s	40	0.14	0.15	0.50	1 12	1:31	1.36	1.1	200	86.9	5.36	0.85	0.48	0.15	2220
site			0 0	0	.28	.41	64.	24.5	.57	8.8	25.	200							8.05	1	1 5	1	4 44 7	0	0	00	. 8	.26	×.	¥ 8	3.5	50.	EX.	5 F.	0.27	800	
Area above Navarro Mills Demsite	: Rainfall Loss : excess (inches): (inches		0.25																3.55 8	- 245 sq. mi		1		17	0.18	500										0.18	
Arres Navarro	170		0.25																	A 2	Tehuncara Creek above head of Tennessee Colony Beservo	2000														0.18	
	8		000																1 11.60		La C	10	88 : mair es) : (inc		0												
Area above Bardwell Damsite	: Painfal Loss : excess (inches): (inches		nyo		0.53									•	•			•	13.01	30. mi	1 3 %	Baine	s excess	0	and it	0.0									0.35		
Arres	223		9.30												٠	•	ı		3.70	A TAZ	Richland Creek Hils Demsite		s):(inches):													2000	
	Rainfall -: Average : excess : rainfall: (inches) : (inches):	8		0.64	0.83	1.00	1.09	1.18	1.65	12.4		1.28					1	•	16.71	0		15		0.20	0.2	0.20	18	1.80	1.86	3.6	100.1	6.56	3.24	X 2.1	0.65	1000	
oove	: Rainfall : excess		0	0.25	0.38	7.0	200	0.07	0.72	0.0	100	0.75				,			10.22	10. ml.	B G B	Ba me	Loss excess inches): (inches	0	0 0	0 0	1.0	1.25	1.30	9.1.	3.31	18	5.49	10	0.27	800	
Area above Lavon Dam	: Loss :(inches)	0,0	0.30	0.30	0.30	8	8.0	0.0	2,8	28	200	0.30		,			1		3.49	87.	Chambers Creek - Bar Damsite to head of Tennessee Colony Rese	1	_ ~	0.17	0.18	0 28 C	0.30	0.30	0.30	8.6	30	0.3	8.8	3.8	0.30	00.0	
	Average rainfall (inches)	01.0	0.30	2	0.68	±	0.89	16.0	7.00	1.02	4.33	1.05		ı			1	,	13.71	D. A	Chambers Densit	Average	(inches)	0.17	0.18	200	1.34	1.55	1.60	01.0	3.61	8.26	2:	48	0.57	0.18	
Dan	excess (inches)	C	0	0	0.01	09.0	81	100	8.8	1.03	4.34	0.83	0.44	0.26		1			11.24	. 107	and of	Bainfall	excess (inches)	0	00	00	1.06	1.26	1.3	9.42	3.35	8.03	2.5	36	0.28	800	
Area above	Painfall Loss excess (inches); (inches	01.0	0.16	0.21	0.30	0.30	0.30	3,8	3,6	200	0.30	0.30	0.30	0.30		í		,	3.73	D. A. = 754 sq. mi	dar Creek to head Tennessee Colony Reservoir	1.	Loss :	0.17	0.18	200	0.30	0.30	0.30	8.0	0.30	0.30	0.30	0.30	0.30	0.18	
. 7	Average : rainfall: (inches):	0.10	91.0	0.21	o.3	8.0	8.7	3.	1 13	200	4	1.13	0.74	95.0			,		15.03	D. A.	Cedar Cr Tennes	Avertion	(inches):	0.17	0.10	0.00	1.36	1.8	1.61	1.75	3.65	8.33	2.83	7.5	88	0.18	
	13 7	c	0	70.0	0.27	24.0	*	40.0	17.0	8.5	00.4	0.75		,	,	,	,	ĸ	36.01		of East: nessee :	- Lluju		0	00	0.03	200	1.8	1.63	1.1	4.07	02.6	3.08	0.91	0.39	.00	
Area above	Loss : c	40.0	0.38	0,60	0.60	8.0	8.00	800	8.8	8.9	09.0	09.0							6.62 1	645 sq. md	ty Rver-mouth of to head of Tenner Colony Reservoir	- Ba	loss : excess inches):(inches	0.21	70.0											28.00	
Great	Average : : Fainfall rainfall : Loss : excess (inches):(inches):(inches	4c 0	0.38	19.0	0.87	1.01	1.14	1.54	7.7	57.0	2.5	1.8				ı	1		47.71	D. A. = 645	Trinity Maver-mouth of Ra Fork to head of Tennessee Colony Reservoir	AVOTREE	77													22.0	
9	Rainfall -: Averses : ra (inches) : (i	c	0	0	đ:	.16	.23	3,8	2,8	190	143	.38							1 14.9		1 .	Rainfall -: Av	-											74.0		000	
a above burtain Den	se hes):		0.27																34	2 89. 画	Trinity River om to mouth	. Part	18													0.14	
Area Bagle Mo	Average : Lo rainfall: Lo (inches): (inches)			0 64.0															81 6.	D. A. = 532 sq.	Pork n D	. 92e	:rainfall: Los :(inches):(inch											0.77		0.14	
			0														•		12.81			Rainfall - Average	ss rair	0												000	
Area above dgeport Dam	10										\$.0		•	1	•	ī	1		1.01	59. mf.	Area above Lakeview Demoite	Rains	s : excess		3.0	250								0.87			
Area above Bridgeport Dam	:Average : :Rainfall- rainfall: Loss : excess : (inches):(inches)		0.10											•	¥			1	3.88	D. A. = 272 sq. mf.	Area above Lakeview Dem	-	annual: Loss : excess inches) (inches)													0.00	
	12	0.0	0.10											,			ř.		4.89	-		Reinfall - Average	37 14													179	
2 2	: Rainfall Loss : excess (inches): (inches)	0	0	0.24	XX	0 00	0.00	1.07	1.11	2.48	6.42	1.11		,	·				15.53	H.	Elm Fork Triffly River be- low Reservoirs & Triffly River to mouth of Bast Fork	Seinfal	1: Loss : excess):(inches):(inches)	0		0.0	76.0	1.08	000	27.1	2.61	6.35	N.F.	. c	0.15	000	
Area above Benhrook Dan		0.0	0.48	19.0	09.00	8.5	899	99.0	0,60	09:0	09.0	09.0		,		,	,		6.80	D. A. * 725 sq. mt.	ervoirs a		[Inches	0.14	0.18	8	0.30	0.30	0.30	0.30	0.30	0.30	0,0	3.0	0.30	0.15	
Ä	Average reinfall (inches)	0.31	0.48	0.85	77.7	1 45	1 57	1.67	1.7	3.08	7.00	17.7	r	,	,	:	ı		22.33	D. A.	Elm Fork low Res River to	Average	(Inches)	0.14	200	0.22	1.29	1.38	50.7	8.9	2,91	6,65	7.00	0.81	0.45	0.00	
	fine in 6-bour periods	*	174	17.	* "	n iz	3.5	- 00	0	10	7	N	13	7.6	57	01	100	70	Total			Time in	6-bour periods	H	u (*	1-1	15	101	-0	00	10	11	2 5	13.7	57	119	

- 107. SPILLWAY DESIGN FLOOD HYDROGRAPHS. The spillway design hydrographs representing flow into full reservoir were determined for Lakeview, Roanoke, Grapevine, Aubrey, and Garza-Little Elm Reservoirs by applying the appropriate rainfall-excess values given in table 47 to the appropriate unit hydrographs given in table 45, and adding to the resultant flood hydrographs the runoff from the reservoir surfaces (assumed at a rate equal to the rate of rainfall). The resulting spillway design flood hydrographs have peak discharges of 372,400; 325,600; and 483,100 second-feet and volumes of 413;400; 780,000; and 952,000 acre-feet for Lakeview, Roanoke, and Aubrey Reservoirs, respectively. The spillway design flood hydrograph for Lakeview Reservoir has been revised subsequent to approval by OCE in February 1961 due to the larger basin shape factor applied to the spillway design rainfall. The spillway design flood hydrograph sed to test the adequacy of the existing spillway at Grapevine Reservoir was obtained by combining the flood hydrograph originating between Grapevine and Roanoke Reservoirs with the outflows from Roanoke Reservoir produced by passage of the flood originating above Roanoke Damsite. This flood hydrograph has a peak discharge of 375,000 second-feet and a volume of 888,600 acre-feet. The spillway design flood hydrograph used to test the adequacy of the existing spillway at Garza-Little Elm Reservoir (Lewisville Dam) was obtained by combining the flood hydrograph originating between Garza-Little Elm and Aubrey Reservoirs with the outflows from Aubrey Reservoir produced by passage of the flood originating above Aubrey Reservoir. The resulting flood hydrograph has a peak discharge of 856,900 secondfeet and a volume of 2,114,100 acre-feet.
- 108. In determining the spillway design flood for Tennessee Colony Reservoir, the initial elevation at the upstream reservoirs was established under the assumption that the standard project flood would occur prior to the spillway design flood. An investigation showed that all of the flood-control storage space in the upstream Corps of Engineers reservoirs would be filled by this antecedent flood. Therefore, an initial elevation at top of flood-control pool was adopted for all Corps of Engineers reservoirs and an initial elevation at spillway crest was adopted for the Bridgeport and Eagle Mountain Reservoirs. There are local interest reservoirs other than Bridgeport and Eagle Mountain Reservoir in the Trinity River Basin above Tennessee Colony Reservoir. These reservoirs have also been assumed full in determining the spillway design flood for downstream Corps of Engineers reservoir projects. Also, because of the uncertainty as to the plan of operation for these local interest reservoirs and based upon the usual operation of similar structures in the past, it has been assumed that such projects (except for Bridgeport and Eagle Mountain Reservoirs) would be operated so that the outflow approximates the inflow when the reservoirs are full. In addition, in view of the magnitude of the spillway design flood,

no modifications of flows due to the Soil Conservation Service reservoirs has been assumed during its passage. The spillway design flood hydrographs for incremental areas above Tennessee Colony Reservoir were obtained by applying the appropriate spillway design storm rainfall-excess values given in table 48 and to the appropriate unit hydrographs given in tables 45 and 46. Where these incremental areas included reservoirs, the runoff from the reservoir surface (assumed at a rate equal to the rate of rainfall) was added. The hydrographs above upstream reservoirs were then routed through these reservoirs, the outflows progressively combined with incremental downstream hydrographs and routed to Tennessee Colony where the hydrograph was further increased by the runoff from the surface of Tennessee Colony Reservoir. The resulting spillway design flood hydrograph for flow into full reservoir at Tennessee Colony Reservoir has a peak discharge of 951,800 second-feet, a volume of 10,033,400 acre-feet and includes an estimated base flow of 1,000 second-feet.

109. Spillway design flood hydrographs for natural flow at the damsites were also computed at the proposed reservoirs. The peak discharge for natural flow at Tennessee Colony Damsite reflects the modification resulting from major upstream reservoirs including Navarro Mills Reservoir (under construction) and Bardwell Reservoir (authorized). The spillway design floods for natural flow at Lakeview and Tennessee Colony Damsites were submitted to OCE in February 1961 and approved by OCE in April 1961, subject to certain comments. In accordance with these comments, the 24-hour rainfall curve was modified and, in the case of the Lakeview Reservoir, a ten percent reduction factor was adopted in adjusting the storm rainfall for basin shape. These changes account for the differences between peak discharges at Lakeview and Tennessee Colony Reservoirs as submitted to OCE in February 1961 and those presented in this report. The recommended peak discharges for natural flow at the damsites are given in the following tabulation:

SPILLWAY DESIGN FLOODS - NATURAL FLOW AT DAMSITES

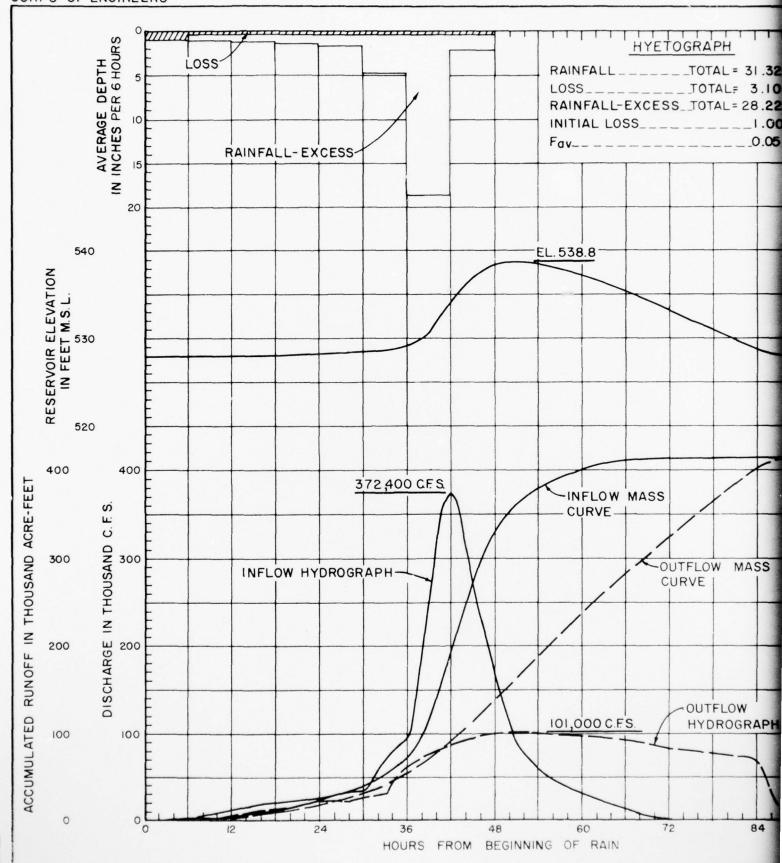
Reservoir :	Peak discharge (cfs)
Lakeview	341,700
Roanoke	313,600
Grapevine (with Roanoke in)	327,300
Aubrey	438,900
Garza-Little Elm (with Aubrey in	640,000
Tennessee Colony	575,600

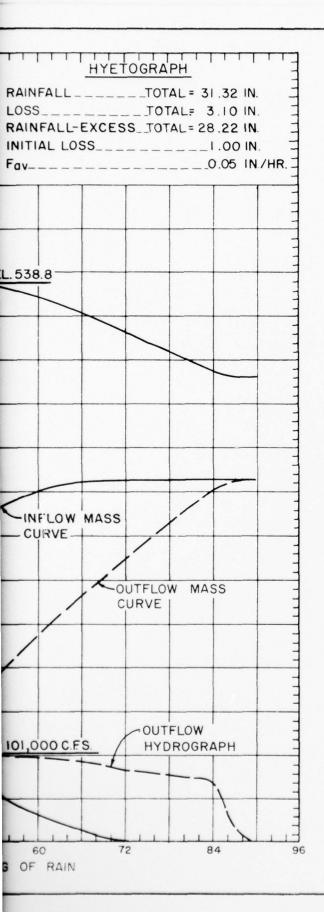
110. SPILLWAY DESIGN FLOOD ROUTINGS. The spillway design flood hydrographs for flow into full reservoir were routed through the recommended reservoirs assuming that the reservoir levels at the beginning of the flood would be at the top of the flood-control storage. These routings were made under an induced surcharge storage method of operation for the gated projects and utilized the full capacity of the flood-control outlet works at each reservoir. Spillway design flood routings were made under the above assumptions. The resultant maximum design water surfaces and peak outflows from the recommended reservoirs are shown in the following tabulation:

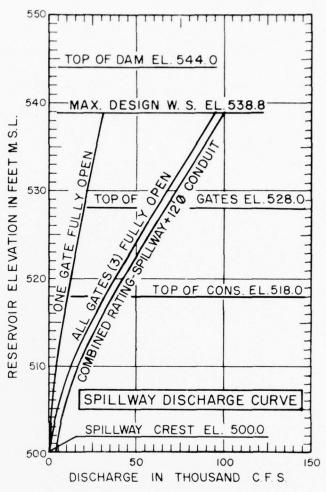
Reservoir :	Maximum design water surface (ft-msl)	:	Peak outflow (cfs)	
Lakeview	538.8		101,000	
Roanoke	625.7		297,000	
Grapevine (with Roanoke i	n) 583.9		232,600	
Aubrey	640.3		350,800	
Garza-Little Elm (with Aubrey in)	556.6		290,000	
Tennessee Colony	297.8		556,000	

^{111.} The spillway design flood inflow-outflow hydrographs and reservoir elevations for the Lakeview, Roanoke, Grapevine, Aubrey, Garza-Little Elm, and Tennessee Colony Reservoirs are shown on plates 40 through 45. The spillway design flood hydrographs for flow into full reservoir are tabulated on table 49.

1







Drainage area 272 square miles.
Outflow controlled by three-40'x 28' gates,
sill el. 500.0, and I-12'0 conduit, invert
el. 460.0.

Reservoir level at top of gates, el. 528.0 at beginning of flood. All discharging facilities in operation during spillway design flood.

TRINITY RIVER AND TRIBUTARIES, TEXAS
MOUNTAIN CREEK
LAKEVIEW RESERVOIR

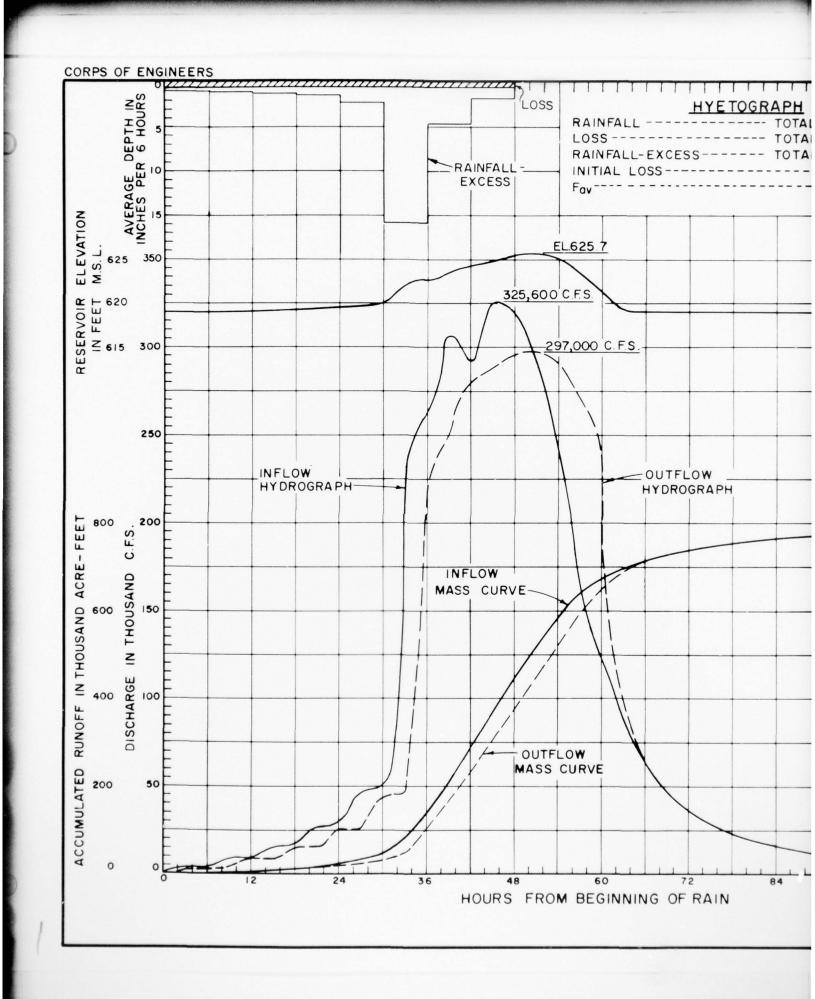
SPILLWAY DESIGN FLOOD

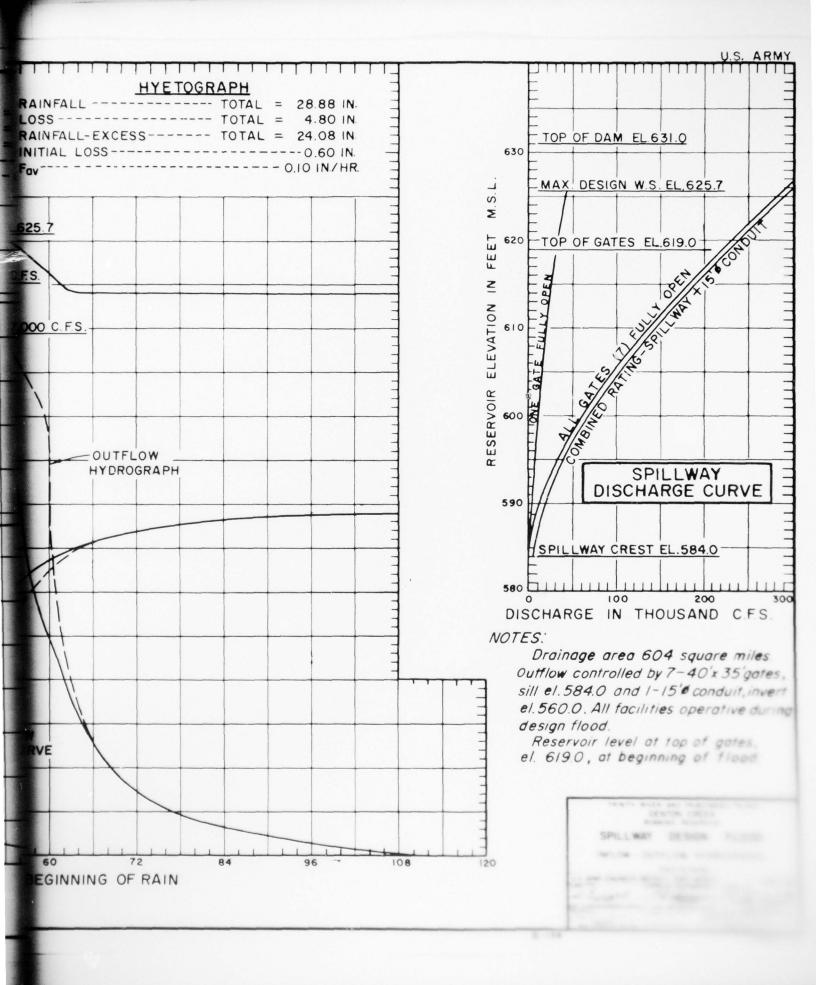
INFLOW - OUTFLOW HYDROGRAPHS

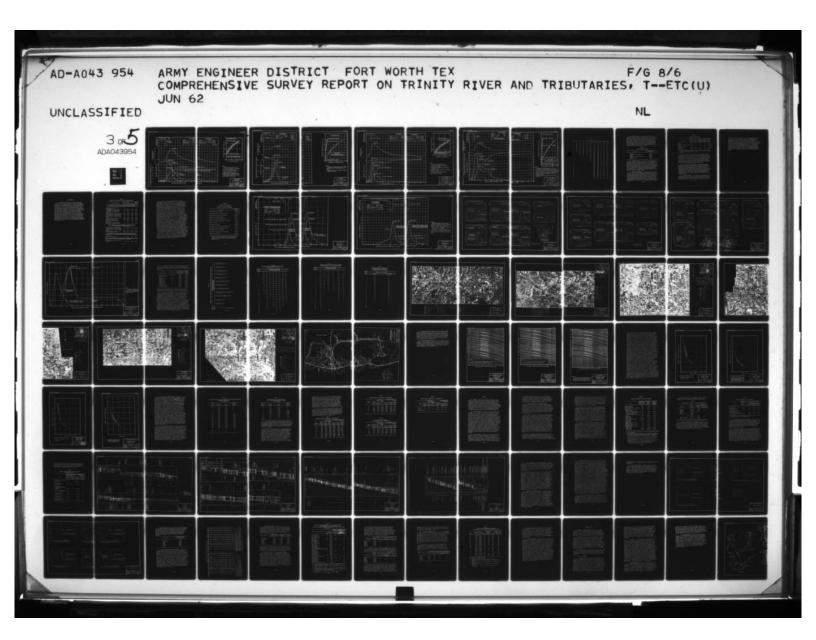
SCALE AS SHOWN

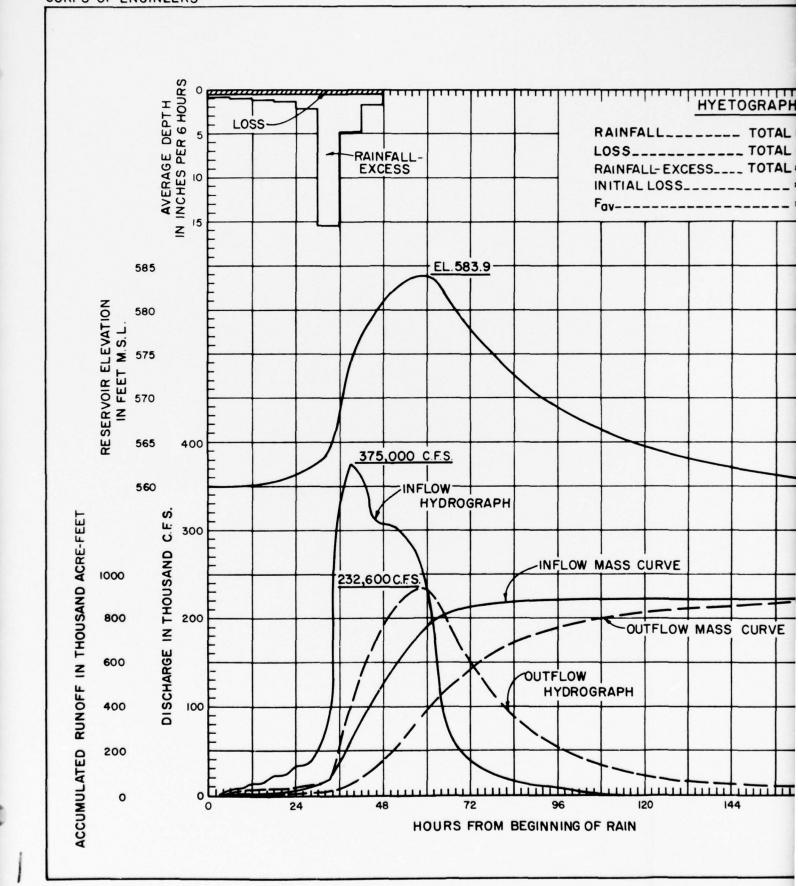
U.S. ARMY ENGINEER DISTRICT, FORT WORTH

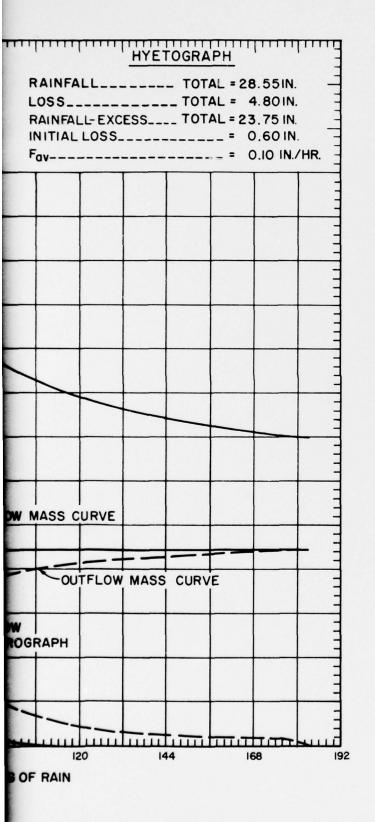
LONG TO THE CONTROL OF THE CONTROL

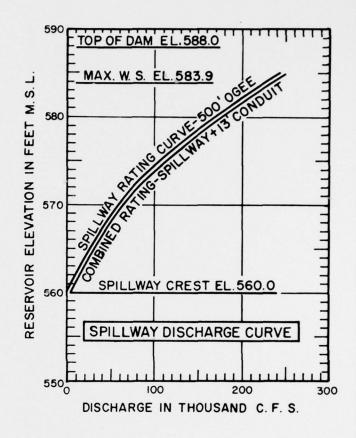












Drainage area 694 square miles.

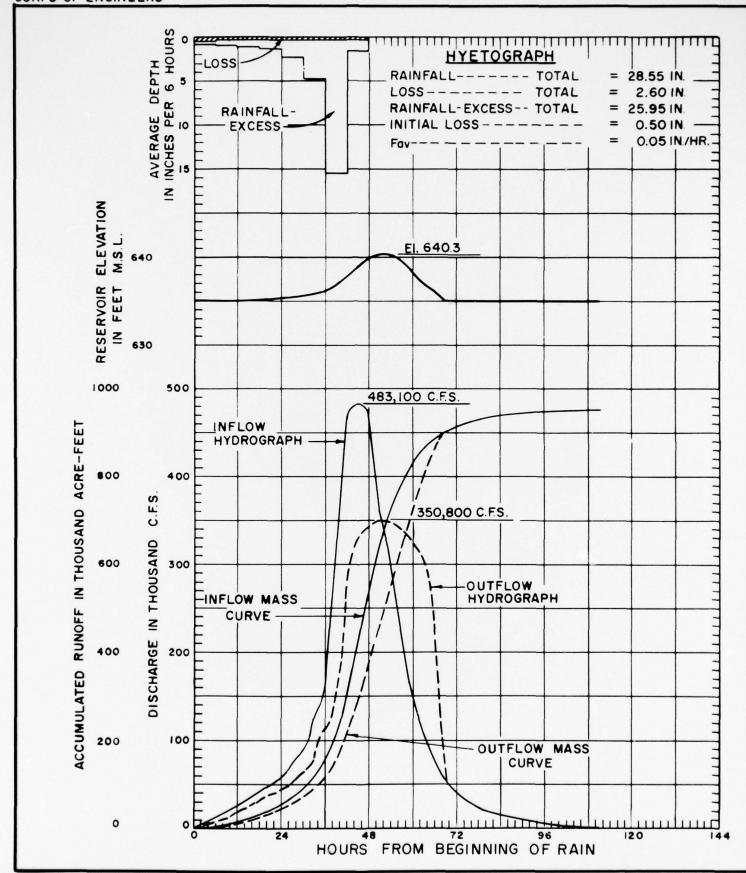
Outflow controlled by I-13' diameter conduit, invert elevation 475.0.

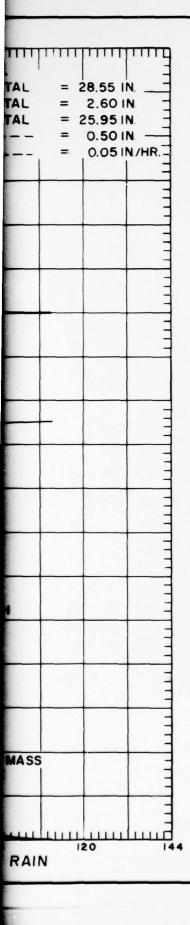
Flood control conduit in operation during spillway design flood.

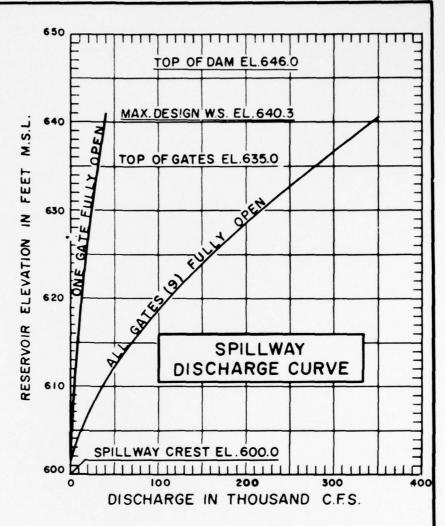
Reservoir level at spillway crest, elevation 560.0, at beginning of flood.

Inflow reflects routed outflow from Roanoke Reservoir upstream.

	TRINITY	DE	NTON CRE	EK	EXAS
	SPILLY	YAY	DESIG	N FL	.00D
1	NFLOW -	- OUT	FLOW H	YDROGE	RAPHS
			CALE AS SHOW		
US ARM		DISTRIC		M MTH	JUNE 1962







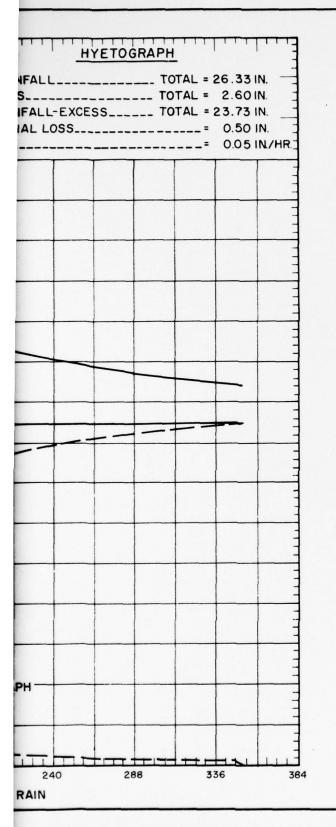
Drainage area 682 square miles. Outflow controlled by nine -40'x 35'gates, sill el. 600.0.

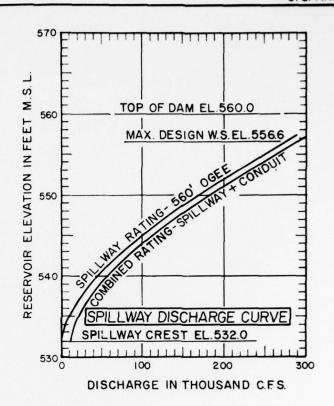
Reservoir level at top of gates, el. 635.0, at beginning of flood.

	TRINITY	Ε	AND TE	RK	IES, TEXA	s	
	SPILLW	AY	DES	GN	FLOC	DD	
	INFLOW -		LOW		OGRAP	нѕ	
W 6	MY ENGINEER C	APPROV		WORTH	APPROVED	JUNE 19	
PE PARE	a Miran			10 400			ï

II - 140

PLATE 4





Drainage area 1,658 square miles.
Outflow controlled by I-16' diameter
conduit, invert el. 448.0.
Flood control conduit operative during
spillway design flood.
Reservoir level at spillway crest, el.532.0,
at beginning of flood.

Inflow reflects routed outlow from Aubrey Reservoir upstream.

TRINITY RIVER AND TRIBUTARIES, TEXAS
ELM FORK
GARZA-LITTLE ELM RESERVOIR

SPILLWAY DESIGN FLOOD

INFLOW - OUTFLOW HYDROGRAPHS

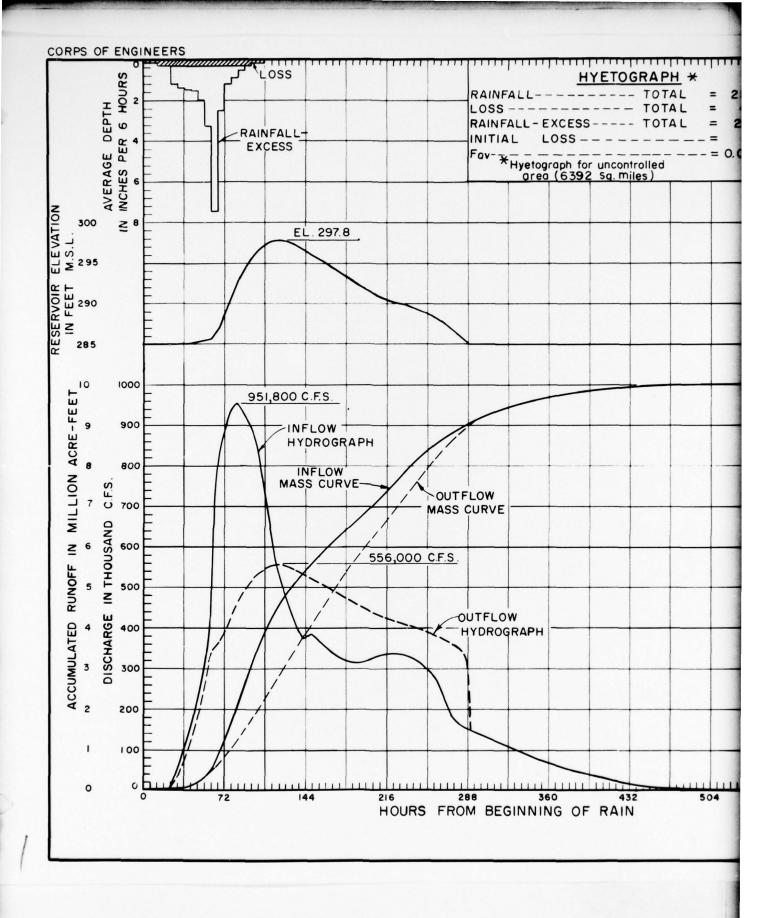
SCALE AS SHOWN

US ARMY ENGINEER DISTRICT, FORT WORTH

AND TO ARMY ENG

II - 141

PLATE 44



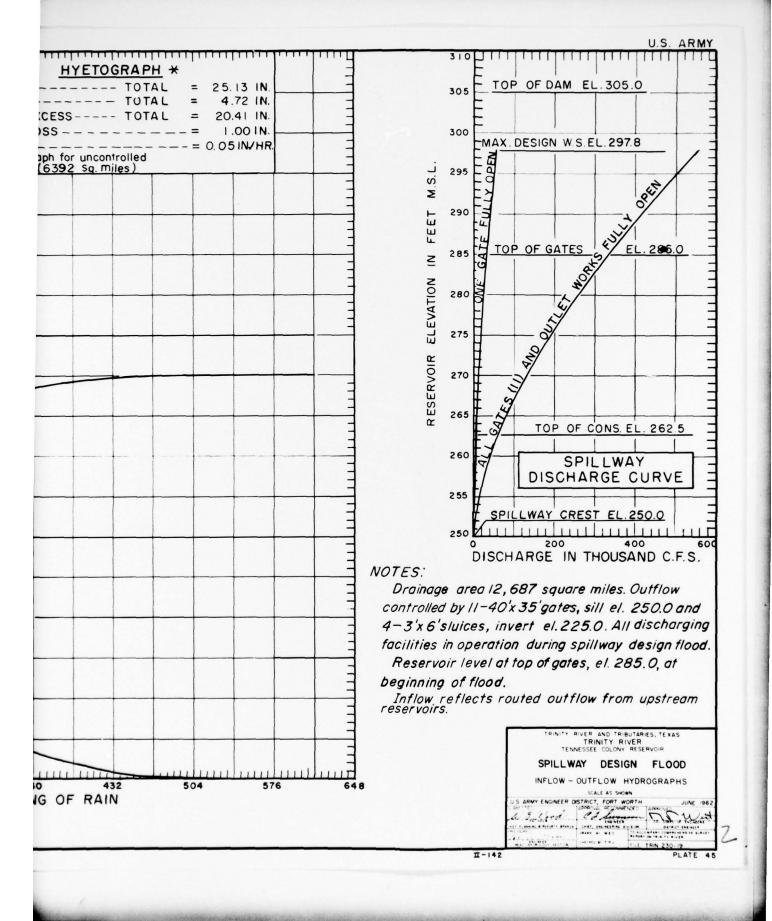


TABLE +9
SPILLHAY DESIGN PLOOD HYDROGRAPHS FOR TRINITY RIVER RESERVO)

in :	Reservoir	Roanoke Reservoir	Grapevine Reservoir D.A. 694 sq.mi.	Aubrey Reservoir D.A. = 682 sq.mi	:Gerza-Little Els Re : (Levisville Dan)	: Tennessee Colony Re :(uncontrolled area) :D.A. = 6,392 sq. ml	Reservoir	3-hour	:Tennessee Colony Res (uncontrolled area)	: Reservoir
		D.A 604 sq.ml.						periods		D.A. 12,687 sq
	2,200 2,300 7,000	3,900	1,200 7,700 9,300 14,100	6,900 11,400 18,500	3,900 17,600	3,900 3,900	3,900 3,900	101	53,000 52,000	135,000
	7,000	9,100	9,300	18,500 25,700	28,500 46,200	3,900 4,200 4,200	1,200	103	51,000	125,400
	11,800 16,700 19,700	16,400	15,100 22,700	34,000 41,900 49,400 57,200 71,600 87,000 125,400 164,400	64,000 81,600	5,200	5,200	105	51,000 51,000	123,000
	19,700 23,300	17,400 27,200	22,700 24,200	41,900	81,600 98,100	5,200 5,800	5,200 5,800 5,800	106	51,000	116,000
	26,000	28,300	34,200	49,400 57,200	115,100	5,800	5,800	107	51,000	112,000
	30,500 33,900 67,900	47,200 49,600	36,200 55,500	71,600	115,100 137,100 182,800	32,500	32.500	109	51,000 51,000	106,000
	33,900 67,900	224,100	55,500 95.100	87,000 125,400	182,800 236,900	53,100 78,400	53,100 78,400 103,300	110	50,000	102,000
	94,500	261,600	95,100 328,000	164,400	308,900	103,300	103,300	112	49,900 49,000	98,900 95,000
	252,200 372,400	306,400 291,700	375,000	309,900 458,500	420,000 671,000	131,800 161,400	131,800 161,400	113	46,000	91,000 88,000
	274,000	325,600	362,500 316,200	483,100	896.000	194,300	194,300	114	44,000 42,000	84,400 81,000
	170,900	320,300 291,500	307,500 306,400	471,200 357,300	825,300 778,800	194,300 225,700 268,400	194,300 225,700 268,500	116	40,000	81,000 78,600
	59,800	241,200	293,300 274,600	297,500	717,800	309,300		118	38,600 37,000	76,000
	41,800 30,200	165,400	274,600	215,500 149,600	652,500 566,600	386,100	368,200 459,500 648,400 814,400	119	36,000	74,000
	20,900	86.800	147,000	107,000	402,500	459,300 648,200	648,400	121	35,000 34,000	71,000 68,000
	12,200	64,700 47,100	73,600 94,000	73,000	250,200 185,700	813,900	814,400	122	33,000	65,000
	1,300	35,600	39,800	53,700 40,400	143,200	836,600 885,700	837,400 887,200 911,500	123	31,000 30,000	62,000
	900 200	29,000	31,000	30,300	114.300	908.800	911,500	125	29,000	60,000 57,000
	100	23,200	25,000 20,600	23,700	93,500 78,700	937,500 946,300	941,500 951,800	126 127	27,000	53,000 51,000
		16,900	17,500	15,000	67,200	944,200 924,400	951,400 933,800	128	24,000	48,000
		14,400	14,900 12,600	12,500 10,000	58,100 50,400	924,400 910,700	933,800 923, 3 00	129	23 000	\$6,000
		9,700	10,300 8,200	7,700	43,500 37,300	896,000 871,400	911,300	1.31	22,000 21,000	45,000 84,000
		7,500 5,300	6,100	5,600 3,600	37,300 31,700	871,400 831,200	891,400 856,700	132	19,800	42,800
		3,300	4,100	1,900	26,600	784,200	814.700	134	17,000 16,000	39,000
		1,300	2,200	300 100	22,100 18,600	731.300	767,300 717,500 665,400	135	15,000	96,400
		200	500	0	15,900	674,100 615,200	665,400	136	14,000	34,000 32,000
		100	200		13,700 11,800 10,100	964.300	620,500	138	. 11,000	30,000 28,000
			0		10,100	515,000 470,400 428,300	578,000 540,900	139	10,000	26,000
					8,600	428,300		141	8,000	25,000
					7,200 6.000	390,900	477,900 447,600	142	7,000 5,300	22,400
					5,000	354,100 323,700 296,500	423,200 403,500 366,900	143 144	5,000	19,000
					4,000 3,300	296,500	403,500 388.900	145 146	4,000 2,500	18,000
					2,600	253,000	379,000 372,400 387,800 386,500 378,600	147	1,600	14,600
					2,000 1,500	236,400	372,400	148	1,400	13,400
					1,100	232,000 217,600	386,500	149 150	1,300	13,300
					700 500	217,600	378,600	1.51	1,100	12,400
					300	196,000	368,300 360,300	152 153	1,000	12,000
					100	186.300	353,300	154	1,000	11,000
						178,900 171,300	344,900 338,300	155 156	1,000	10,300
						163,900	330,900	157	1,000	10,000
						155,500 150,700	324,500 323,100	158 159	1,000	9,000
						143,300	319,500	160	1,000	9,000
						138,300	317,500	161	1,000	9,000 8,000
						132,100	319,500 317,500 317,200 317,600	163	1,000	7,000
						129,000	318,000	164 165	1,000	7,000
						127,400 125,600	321,100 322,000	166	1,000	7,000
						124,700 123,600	323,200	167 168	1,000	6,000
						123,200 122,700	323,200 324,800 327,400 328,800 331,500 333,700	169	1,000	5,500
						122,700 124,400	328,800	170 171 172	1,000	5,000
						125,700	333,700	172	1,000	4,400
						126,500 126,800	335,500 337,800 339,200	173 174	1,000	4,000 3,600
						126,800	337,800	174	1,000	3,400
						128,600	339.600	175 176	1,000	3,200
						126,400 124,000	336,400 333,000 328,000	177 178	1,000	2,900
						121,000	328,000	179	1,000	2,900
						119,000	325,000	180	1,000	2,600
						118,000 116,000	320,000 314,000	181	1,000	2,500
						113,000	314,000 308,000	183	1,000	2,300
						109,000	300,000	184 185	1,000	2,200
						103,200	283,800	186	1,000	2,200
						97,000 79.000	283,800 272,000 245,000	187 188	1,000	2,100
						79,000 67,000	222,000	189	1,000	2,100
						63,800 61,000	205 800	190	1,000	1,900
						59,000	191,000 176,400	191	1,000	1,600
						59,000 58,000	170,000	193	1,000	1,600
						57,000 56,000	162,000	194 195	1,000	1,500
						55,000	158,000 153,000	196	1,000	1,500
						55,000	150,000	197	1,000	1,400
						54,000 53,600	145,000 141,600	198 199	1,000	1,200
						53,000				1,200

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112. GUIDE TAKING LINE. The guide taking line for the recommended reservoirs has been based upon the policy for real estate acquisition set forth in Change 9, dated March 9, 1962, of EM 405-2-150. The upper guide contour has been established at three feet above the top of flood-control storage at all reservoirs except Roanoke where a freeboard of five feet was used. The upper guide contours thus established have been adopted throughout the entire reservoirs areas. More detailed studies will be made during preconstruction planning stages to evaluate the backwater effects on the upper reaches of the reservoirs. The adopted elevations for the upper guide contour are summarized in table 50.

TABLE 50
UPPER GUIDE CONTOUR LEVELS

	:	Upper guide contour
Reservoir	<u>:</u>	(ft-msl)
Roanoke		624.0
Grapevine (with Roanoke in	1)	563.0
Aubrey		638.0
Garza-Little Elm (with Au	orey in)	535.0
Lakeview		531.0
Tennessee Colony		288.0

113. RELOCATION CRITERIA. The criteria for alterations and relocations is based on the maximum elevation of the 50-year reservoir operation, resulting from flood occurences on a full conservation pool after 50 years of sediment deposition, plus freeboard. In the upper portions of the main part of a reservoir and on tributary arms the foregoing criterion or the envelope curve of the backwater profile for the 50-year reservoir operation plus freeboard will be adopted. For the purpose of this report the same elevations adopted for the upper guide taking line in paragraph 112 have been adopted as the basis for relocation estimates. More detailed studies will be made during preconstruction planning stages.

114. FREEBOARD REQUIREMENTS. - Freeboard requirements for the recommended projects were determined in accordance with the method set forth in the minutes of a "Conference on Determination of Freeboard Requirements for McGee Bend Dam, Angelina River, Texas," held in the Fort Worth District Office on June 15, 1956. Computations for wave heights and wave runup were based on the computed effective fetch at the maximum water surface for each reservoir site. The computed wave height and total freeboard for an overland velocity of 40 miles per hour (52 miles per hour over water) was adopted as a basis for design. The results of these computations are summarized in table 51.

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TABLE 51
FREEBOARD REQUIREMENTS

Reservoir	: sur	ation:	fetch	: Total : e:required : :freeboard: :(feet)(1):	freeboard provided	of dam
Roanoke Grapevine (with Roanoke		25.7	3.6 4.0	4.5	5.3 4.1	631.0 588.0(2)
Aubrey Garza-Little Elm (with		40.3	5.6	5.5	5.7	646.0
Aubrey in) Lakeview		56.6 38.8	7·3 2·9	5.6 4.3	3.4 5.2	560.0(2) 544.0
Tennessee Colony	2	97.8	9.2	7.4	7.2	305.0

- (1) Based on an overland wind velocity of 40 miles per hour (52 miles per hour over water) and computed wind tide.
- (2) As built.
- 115. The freeboards originally provided at the existing Grapevine and Garza-Little Elm Reservoirs were based upon spillway design storm rainfall data furnished by the Hydrometeorological Section of the United States Weather Bureau on February 11, 1946. Under these spillway design criteria, the freeboards at these two reservoirs are adequate either with or without the Roanoke and Aubrey Reservoirs upstream. However, as indicated in table 51, when the spillway design storm is based upon Hydrometeorological Report No. 33, the freeboards available at Grapevine and Garza-Little Elm Reservoirs are less than the minimum of 5 feet that is usually considered desirable for earthen dams.
- 116. To further check the adequacy of the freeboard, spillway design flood routings (based upon present criteria) were made for Grapevine and Garza-Little Elm Reservoirs with the initial elevations established at the maximum reservoir levels reached in period of record routings for the flood of April-June 1957 under 2020 conditions of watershed development. Under these routing conditions, the maximum water surfaces produced at Grapevine and Garza-Little Elm Reservoirs were at elevations 583.5 and 553.2, respectively, and would provide freeboards of 4.5 and 6.8 feet, respectively. Based upon the foregoing the available freeboards at Grapevine and Garza-Little Elm Reservoirs are considered adequate.
- 117. HYDROLOGIC NETWORK.- It is proposed to supplement the existing rainfall and streamflow stations by expanding the hydroclimatic and hydrologic reporting networks on the Trinity River Basin. The records and reports will be used to update hydrologic design criteria for preconstruction planning; in connection with construction activities; to

prescribe flood-control regulations for the reservoir system; and in connection with the navigation project. The expanded network will include inflow and outflow stations and reservoir level gages at each reservoir and headwater and tailwater gages at each of the navigation locks and dams. Evaporation and recording rainfall stations will also be provided at each of the recommended reservoirs. Construction of the recommended multiple-purpose channel would involve relocation of some of the existing stream-gaging stations as well as establishment of new stations. Additional stream-gaging stations will also be established on selected tributaries of the Trinity River downstream from the reservoir projects to assist in the regulation of the flood-control storage. Detailed requirements for the complete hydrologic network will be presented in connection with preconstruction planning studies.

LOCAL PROTECTION

118. DESIGN STORM FOR FLOODWAY AND CHANNEL IMPROVEMENT. -Standard project storms were developed and adopted as the design storms for the recommended West Fork Floodway, Elm Fork Floodway, extension of the Dallas Floodway, and the channel improvement on Duck Creek. A standard project storm was not developed for the Liberty project. In lieu thereof, the standard project flood hydrograph was assumed equal to 50 percent of the probable maximum flood hydrograph. Except for the Liberty project, located in the lower basin, standard project storms for the various areas studied were determined in accordance with procedures set forth in EM 1110-2-1411 (Civil Works Engineer Bulletin No. 52-8 dated March 26, 1952). The standard project storm was centered at various locations on the West Fork, Elm Fork, Mountain Creek, and Duck Creek watersheds to obtain the most critical transposition. The most critical transposition with respect to each project was then adopted as the design storm for that project. The adopted standard project storm rainfall and rainfall-excess used to determine design floods for the West Fork Floodway, Elm Fork Floodway, the extension of Dallas Floodway, and Duck Creek Channel Improvement are shown in table 52.

TABLE 52
STANDARD PROJECT STORM RAINFALL AND RAINFALL-EXCESS

And the second s								
	_	: Total		:Rainfall-				
Incremental area	: area	:rainfal]						
	:(sq.mi.):(inches):(inches):(inches)				
Storm centered over uncontrolle	ed area of	West For	k waters	hed				
(Used for design of lower West Fork	Floodway	& Dallas	Floodway	Extension)				
West Fork Trinity River above								
Bridgeport Dam	1,114	11.15	4.93	6.22				
Bridgeport Dam to Boyd Damsite	593	11.83	5.07	6.76				
Boyd Damsite to Eagle Mtn Dam	267	14.41	5.44	8.97				
Clear Fork Trinity River above								
Benbrook Dam	433	12.19	5.13	7.06				
Mountain Creek above Lakeview Damsit	e 272	13.42	3.39	10.03				
Denton Creek above Roanoke Damsite	604	12.20	5.13	7.07				
Roanoke Damsite to Grapevine Dam	90	15.05	5.52	9.53				
Elm Fork Trinity River above Aubrey								
Damsite	682	9.25	2.98	6.27				
Aubrey Damsite to Lewisville Dam	976	10.61	3.17	7.44				
West Fork uncontrolled area	823	15.64	7.16	8.48				
Elm Fork uncontrolled area	226	14.18	6.83	7.35				
Trinity River from Elm Fork to								
Dallas Gage	40	16.43	3.66	12.77				
Trinity River from Dallas Gage to								
below mouth of White Rock Creek	173	13.50	3.42	10.08				
Starm centared over uncentrall	ed area	of Fin For	ak matemal					
Storm centered over uncontrolled area of Elm Fork watershed (Used for design of Elm Fork Floodway)								
	Dim Polk							
Denton Creek above Roanoke Damsite	604	11.60	4.20	7.40				
Roanoke Damsite to Grapevine Dam	90	15.20	4.70	10.50				
Elm Fork Trinity River above Aubrey								
Damsite	682	12,90	3.00	9.90				
Aubrey Damsite to Lewisville Dam	976	13 40	3.10	10.30				
Elm Fork uncontrolled area	226	18.30	6.80	11.50				
Otania santanai au Maratata Oncolo		- have T	leased are D					
Storm centered on Mountain Creek								
(Used for design of West Fork Floodw Creek Dam)	ay on Mou	intain Cre	ek perow	Mountain				
Mountain Creek watershed	305	16.40	3.27	13.13				
Storm centered on Duck Creek watersh ment (Used for design of Duck Creek				el improve-				
Duck Creek watershed above mouth of Long Branch	24.3	3 21.40	3.20	18.20				

119. DESIGN FLOOD FOR PROPOSED FLOODWAYS AND CHANNEL IMPROVEMENTS .- Studies indicated that, for a flood of the magnitude of the standard project flood, the highest discharge at Liberty would result from releases from Tennessee Colony Reservoir rather than from floods generated on the area between Tennessee Colony Damsite and Liberty. Therefore, 50 percent of the spillway design flood hydrograph for Tennessee Colony Reservoir shown in table 49, was used as the standard project flood hydrograph above the reservoir. A flood hydrograph was also developed for the area between Tennessee Colony Damsite and Liberty. However, because of the length of travel time from Tennessee Colony Reservoir to Liberty, the local area was found to contribute little flow at the time that maximum releases from Tennessee Colony Reservoir would reach Liberty. The standard project flood hydrograph for Duck Creek was determined by applying one-hour increments of the appropriate standard project storm rainfall-excess shown in table 52 to the appropriate unit hydrograph shown in table 46. The standard project flood hydrographs for all other projects considered were obtained as follows. Six-hour increments of the appropriate standard project storm rainfall excess shown in table 52 for the areas above upstream reservoirs and for increments of the uncontrolled drainage areas between the upstream reservoirs and the projects considered were applied to the respective unit hydrographs shown in tables 45 and 46 to determine standard project flood hydrographs originating on each incremental area. Where the incremental areas included reservoirs, the runoff from the reservoir surface (assumed at a rate equal to the rate of rainfall) was added. The flood hydrographs above existing and proposed reservoirs were routed through the reservoirs and the outflows and hydrographs for incremental downstream areas were progressively combined and routed downstream to the site of each of the projects considered. A study of system routings of the major floods on the basin indicated the probable occurrence of a flood antecedent to the standard project flood of sufficient volume to fill approximately one-third of the flood-control storage provided in the reservoirs. Therefore, in all of the standard project flood routings referred to above, it was assumed that the flood-control pools of upstream reservoirs would be one-third full at the beginning of the standard project flood. Peak discharges for the standard project flood for the recommended floodway and channel improvement projects are shown in table 53 and the hydrographs at selected locations are shown on plates 46 through 51.

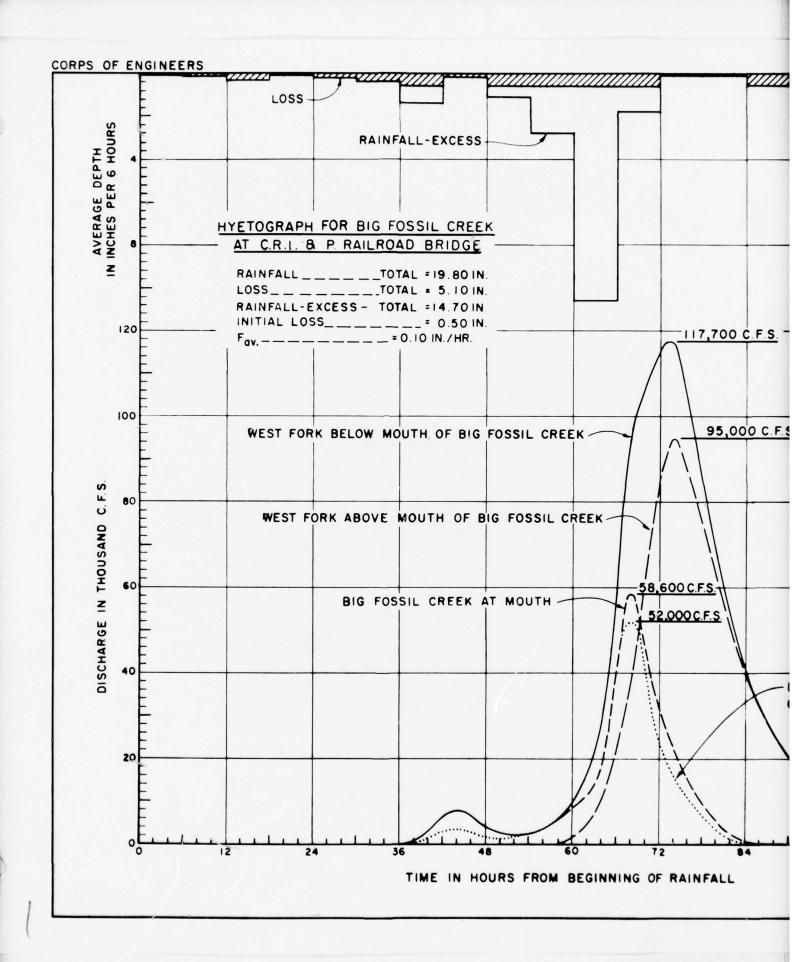
TABLE 53

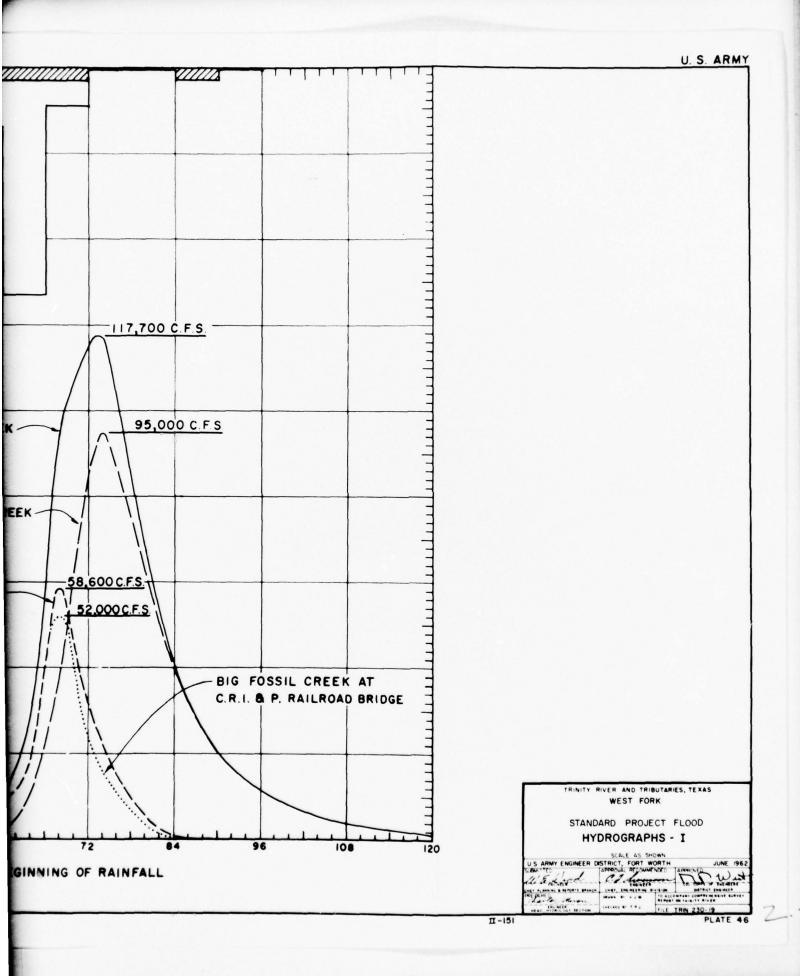
DESIGN FLOOD DISCHARGES

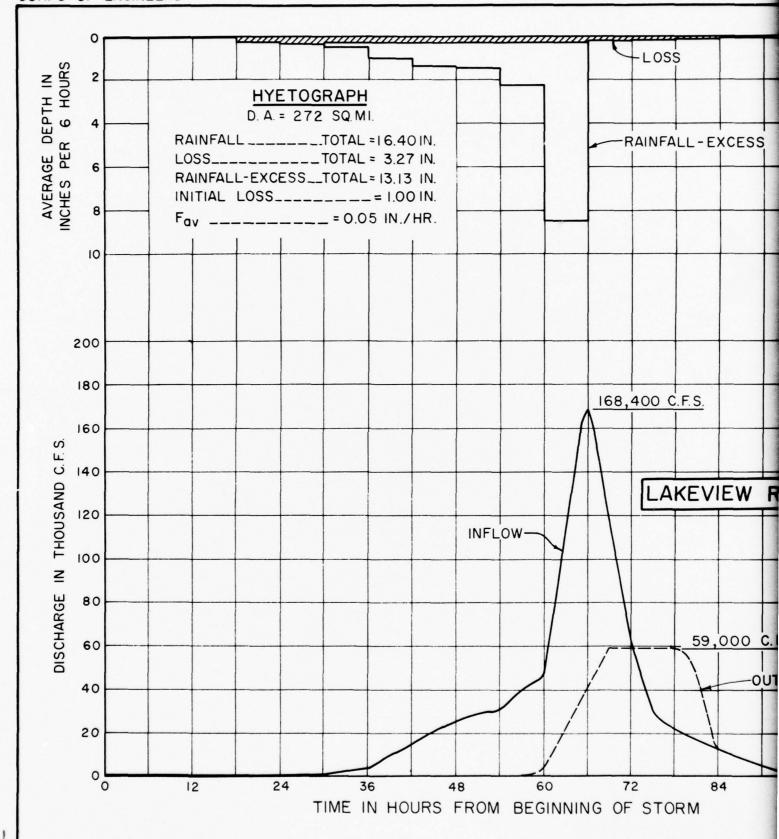
FLOODWAYS AND CHANNEL IMPROVEMENTS

Location	:	Discharge (cfs)
West Fork at Fort Worth Gage		95,000 (1)
West Fork below mouth of Big Fossil Creek		117,700 (1)
West Fork below mouth of Village Creek		138,000
West Fork at Grand Prairie Gage		148,000
West Fork above mouth of Mountain Creek		160,000
Elm Fork at Carrollton (State Hwy 114 bridge)		58,000
Elm Fork at mouth		61,000
Trinity River at Dallas		163,800
Trinity River below mouth of White Rock Creek		174,600
Mountain Creek, Lakeview Damsite to mouth		59,000
Duck Creek at head of improvement		21,500
Duck Creek at downstream end of improvement		40,700
Trinity River at Liberty		180,000

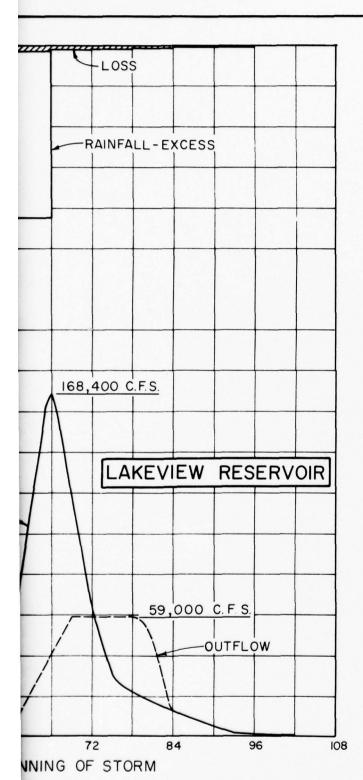
⁽¹⁾ Standard project flood discharges previously determined in conjunction with the design of the existing Fort Worth Floodway and the authorized local protection project on Big Fossil Creek.







U. S. ARMY



NOTES:

Routing through 120-foot ogee spillway controlled by three 40-foot by 28-foot tainter gates, crest at el. 500.0, and 12-foot diameter conduit, intake invert at el. 460.0.

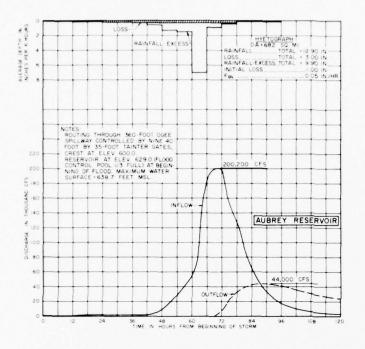
Reservoir at el. 521.6 (flood control pool 1/3 full) at beginning of flood.

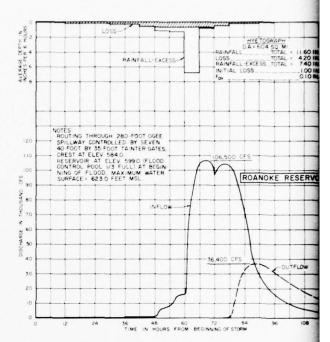
Maximum water surface= 530.0 feet M. S. L.

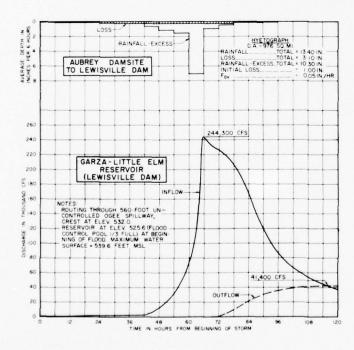
TRINITY RIVER AND TRIBUTARIES, TEXAS

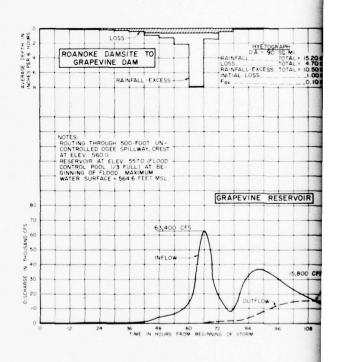
STANDARD PROJECT FLOOD HYDROGRAPHS - II

US ARMY ENGINEER DISTRICT, FORT WORTH JUNE 196









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HYETOGRAPH

DA 604 SQ M

TOTAL
LOSS
TOTAL
RAINFALL EXCESS TOTAL
INITIAL LOSS UNCONTROLLED AREA TES DUTING THROUGH 280-FOOT GEE PILLWAY CONTROLLED BY SEVEN 3-FOOT TAINTER GATES, TEST AT ELEV 5840 99 (FLOOD ESERGING AT ELEV 5941) 99 (FLOOD MAXIMM) WATER 180 (FLOOD MAXIMM) WATER 1874CE 623.0 FEET MSL ROANOKE RESERVOIR SECONDARY PEAK OF 56,300 CF 70 61,000 CFS 60 50 ELM FORK AT MOUTH 40 20 36 48 60 72 84 TIME IN HOURS FROM BEGINNING OF STORM ELM FORK OF LOSS HYETOGRAPH

OA = 90 SQ MI

FRAINFALL TOTAL = 15 20 IN

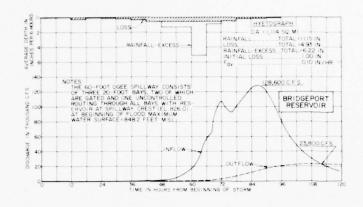
LOSS TOTAL = 4 70 IN

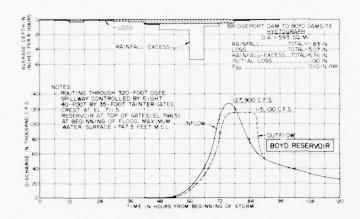
RAINFALL EXCESS TOTAL = 10 50 IN

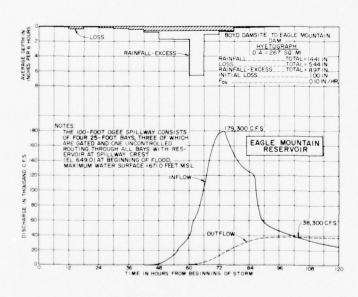
INTIAL LOSS TOTAL = 10 00 IN

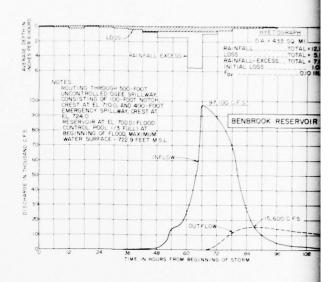
Fov 0 10 IN GRAPEVINE DAM RIVER RAINFALL - EXCESS -AUBREY DAMSITE TES:
UTING THROUGH 500-F00T UNNTROLLED 06EE SPILLWAY, CREST
ELEV 560 0
SERVOIR AT ELEV 5570 (FLOOD
NTROL POOL 1/3 FULL) AT BENNING OF FLOOD MAXIMUM
LTER SURFACE * 564.6 FEET MSL. GARZA-LITTLE ELM RESERVOIR GRAPEVINE RESERVOIR TRINITY R WEST FORK OF TRINITY RIVER 63,400 CFS ISOHYETAL MAP OF STANDARD PROJECT STORM - III 15,800 CFS VOIE: Standard Project Storm has been centered on Elm Fork of Trinity River uncontrolled area of 226 square miles. ELM FORK STANDARD PROJECT FLOOD HYDROGRAPHS - III 36 48 60 72 84 TIME IN HOURS FROM BEGINNING OF STORM US ARMY ENGINEER DISTRICT, FORT WORTH

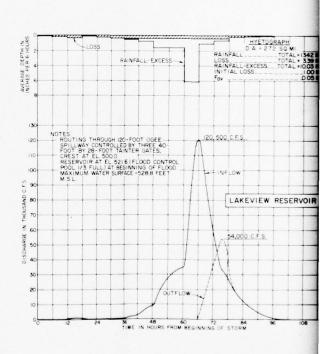
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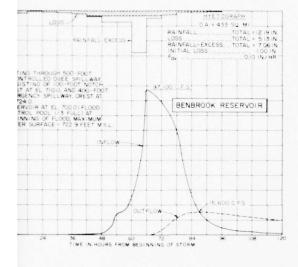


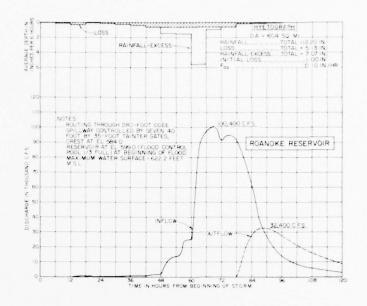


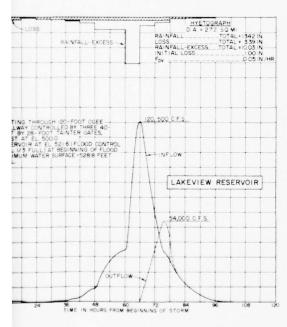


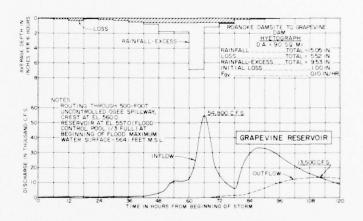












Standard Project Storm has been centered on the 1262 square mile uncontrolled area of the Trinity River above the mouth of White Rock Creek (See isobyetal map on Plate 50)

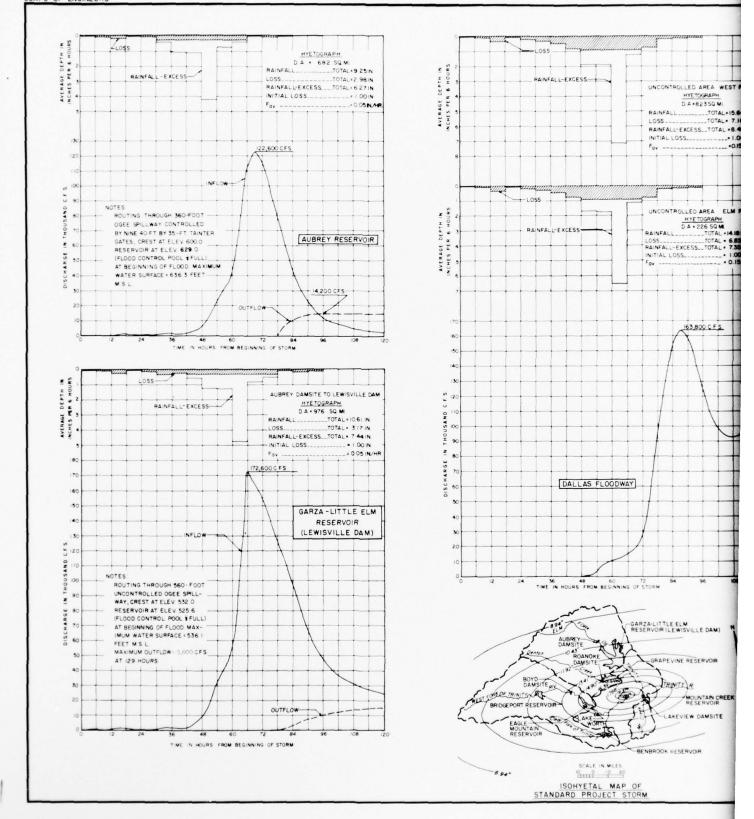
RIVER AND TRIBUTARIES TRINITY RIVER - DALLAS FLOODWAY

STANDARD PROJECT FLOOD HYDROGRAPHS - IV

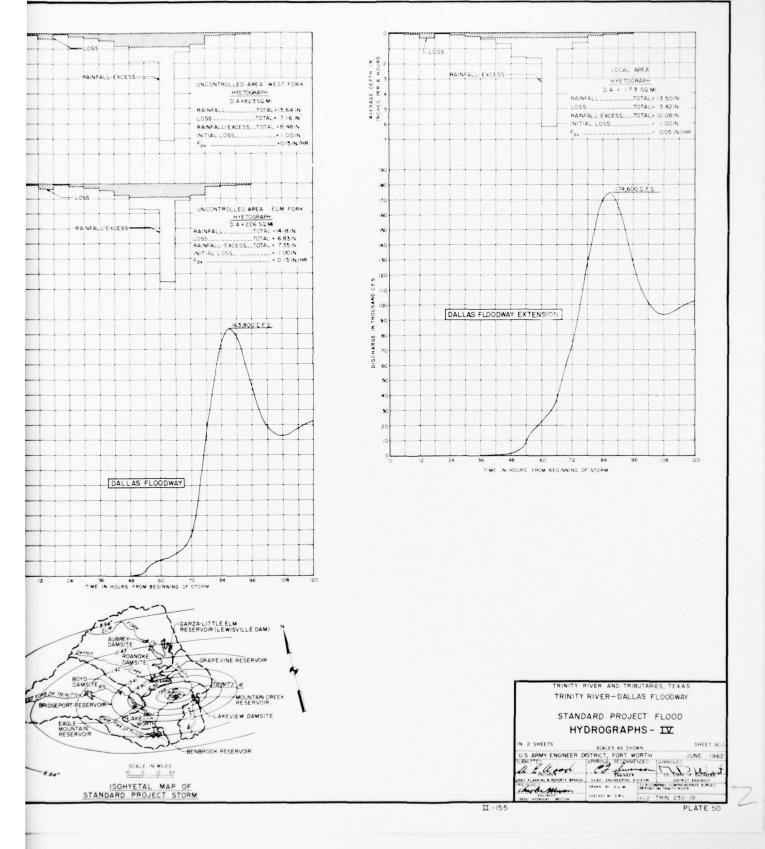
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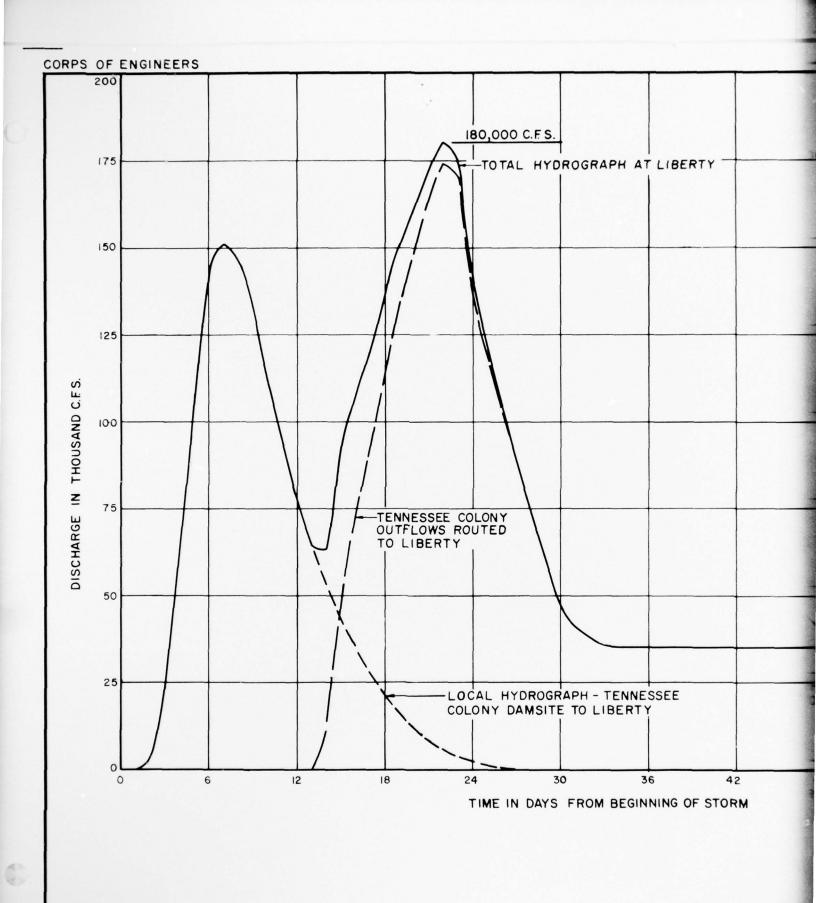
U.S. ARMY ENGINEER DISTRICT, FORT WORTH JUNE 1960

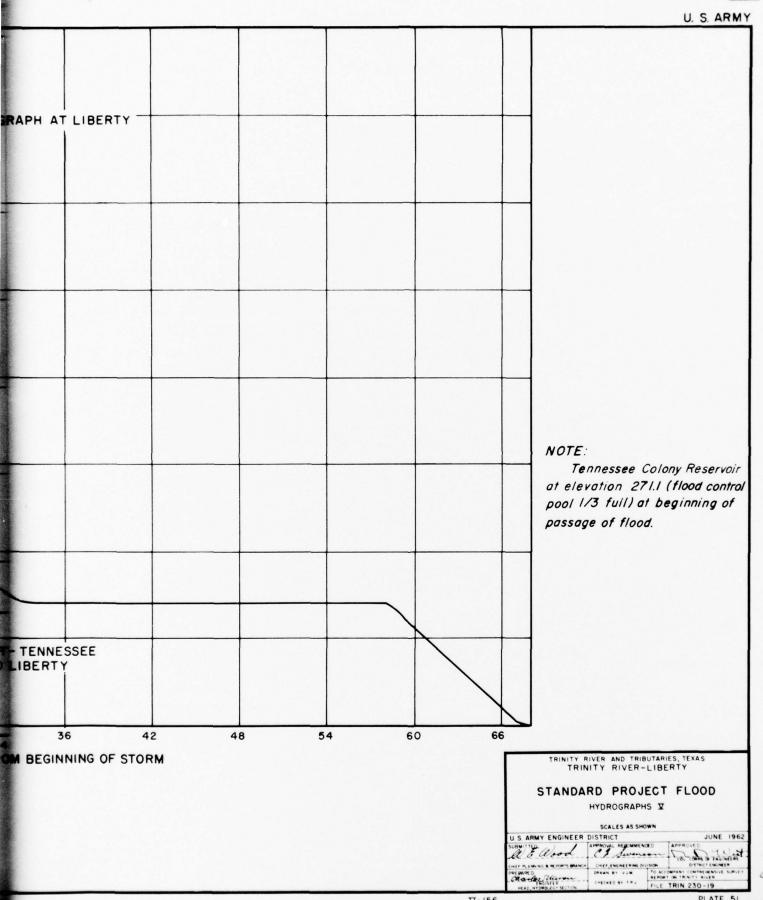
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120. The standard project flood was also adopted as the design flood for all tributary channel improvements considered in connection with the West Fork and Elm Fork Floodways and the Dallas Floodway Extension. These tributaries and their design discharges are given in the following tabulation:

Tributary	Main Stem	Approximate : multiple-purpose: channel mile :	Design discharge (cfs)
Five Mile Creek	Trinity River	321.50	63,500
Honey Springs Branch	•	326.15	4,100
White Rock Creek		326.62	72,100
Elm Fork	"	338.80	61,000
Mountain Creek	West Fork	340.89	59,000
Delaware Creek	n	341.20	17,700
Bear Creek		346.83	72,500
Unnamed Creek		355.13	10,200
Sulphur Branch	"	356.08	8,100
Walker Branch		359.79	25,800
Unnamed Creek	"	361.13	1,890
Big Fossil Creek	n	362.92	52,000
Little Fossil Creek	n	363.68	17,400
White Lake Outfall	n	364.71	2,000

These discharges were adopted for developing backwater profiles, for establishing the grades of levees and overbank fill areas, and for determining the sizes of proposed flood-control channels and floodways.

121. SYNTHETIC UNIT HYDROGRAPHS - INTERIOR DRAINAGE AREAS - The unit hydrograph studies for the Upper Trinity River Basin discussed in paragraph 103 were used as a basis for the selection of Snyder's coefficients used in the development of synthetic one-hour unit hydrographs for interior drainage areas of the recommended West Fork and Elm Fork Floodways and extension of the Dallas Floodway. The adopted coefficients for the interior drainage areas are as follows: West Fork Floodway and Dallas Floodway Extension, Ct = 0.90 and $C_p640 = 420$; Elm Fork Floodway, $C_t = 1.0$ and $C_p = 450$. Unit hydrograph studies for Buffalo Bayou, a tributary of the San Jacinto River which is located adjacent to the Lower Trinity River, were used as a basis for the selection of Snyder's coefficients used in the development of synthetic two-hour unit hydrographs for interior drainage areas of the recommended flood protection for the city of Liberty, Texas. The adopted coefficients for the interior drainage areas are $C_t = 3.0$ and C_p 640 = 300. The adopted synthetic unit hydrographs developed from the foregoing coefficients for interior drainage areas for the West Fork and Elm Fork Floodways, the Dallas Floodway extension and the city of Liberty flood protection project are shown in tables 54 through 57. Plates 52 through 58 show the locations of the various areas considered.

TABLE 54

SYNTHETIC ONE-HOUR UNIT HYDROGRAPHS FOR INTERIOR DRAINAGE FACILITIES - WEST FORK

Time in :					Discharge in second-feet	in seco	nd-feet					
1/2 hour:					Interior	· drainage	ge area					
periods	A	B-1	B-2	0	Ω	E	Œ	D	H	П	J	×
,	85 SF	70	770	275	09	09	9	170	γ	9	,	200
4 (000	0 0		700	0 -	0 1	0 1	2	2	3		603
N	280	170	110	290	145	175	175	390	95	150	180	525
3	230	365	230	930	270	380	530	520	180	560	290	700
†	350	295	570	1,270	520	790	975	430	400	425	195	520
5	180	180	1,130	1,370	850	009	770	305	445	540	115	350
9	110	105	006	1,260	775	350	470	215	385	700	65	245
7	75	20	550	985	580	215	275	150	245	280	04	165
80	70	20	3,0	790	420	155	195	100	165	200	25	115
6	50	30	230	635	300	11.5	150	9	115	140	10	75
10	0	15	160	515	220	20	11.5	35	70	100	5	45
11		0	130	41.0	175	50	8	50	45	69	0	15
12			T 00	320	125	30	09	10	25	35		0
13			70	250	8	10	04	5	10	15		
174			50	185	50	0	80	0	0	0		
15			30	135	80		10					
16			8	8	0		0					
17			10	20								
18			0	8;								
19				0 0								
22				0								

TABLE 55
SYNTHETIC ONE-HOUR UNIT HYDROGRAPHS FOR INTERIOR
DRAINAGE FACILITIES - ELM FORK

Time in :_			Disch	arge i	n secon	d-feet			
1/2-hour:		70	Inte	rior d	rainage	area		**	
periods :	A	В	C	D	E	F	G	H	
1	55	50	40	50	50	50	70	70	
2	200	130	110	130	110	120	160	180	
3	590	260	370	270	210	250	400	470	
4	385	560	700	570	480	480	720	780	
5	205	950	490	800	800	800	1,030	600	
6	155	860	270	710	1,060	1,130	820	420	
7	100	730	180	550	980	980	610	260	
8	60	560	130	400	830	810	420	190	
9	40	440	100	300	680	660	290	140	
10	20	340	70	230	540	530	230	110	
11	10	260	50	190	400	410	180	80	
12	0	200	30	150	290	310	150	60	
13		150	20	120	240	240	120	40	
14		120	10	100	190	190	90	20	
15		100	0	80	160	160	70	10	
16		80		60	130	120	60	0	
17		60		40	110	100	40		
18		40		30	90	70	20		
19		30		20	70	50	10		
20		20		0	50	30	0		
21.		10			40	20			
22		0			20	0			
23					10				
24					0				
					-				

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TABLE 56
SYNTHETIC ONE-HOUR UNIT HYDROGRAPHS FOR INTERIOR DRAINAGE FACILITIES - DALLAS FLOODWAY EXTENSION

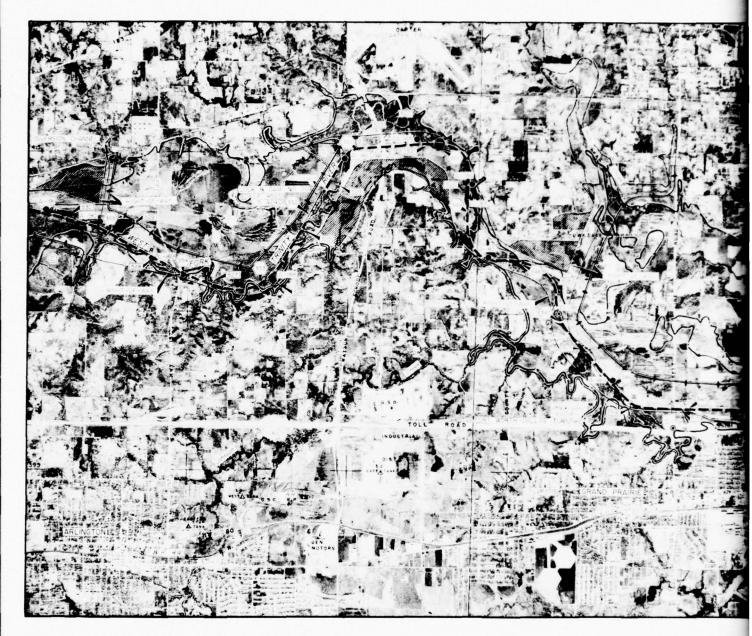
Time in :_		Ī		in second-fee		
1/2-hour:	٨	В	Interior of	drainage area	<u>.</u>	D O
periods :	A	В	C-1	C-2	D-1	D-2
1	170	60	160	50	105	40
2	450	130	500	150	235	90
3	1,080	380	1,750	360	440	190
4	2,070	675	1,060	190	800	400
5	1,670	535	600	110	1,230	600
6	1,160	355	320	70	1,150	520
7	820	215	200	50	920	415
8	570	150	130	40	590	300
9	440	105	80	30	500	205
10	360	75	40	20	380	148
11	31.0	50	20	1.0	305	110
12	270	30	0	0	250	90
13	220	15			205	70
14	190	0			160	50
15	160				125	40
16	130				90	20
17	1.00				55	10
18	80				o	0
19	50					
20	30					
21	20					
22	0					
			11-16	50		

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TABLE 57

SYNTHETIC TWO-HOUR UNIT HYDROGRAPHS FOR INTERIOR DRAINAGE FACILITIES FLOOD PROTECTION - CITY OF LIBERTY

Time in: 2-hour:	Discha	rge in second-feet
periods:	Big Bayou	: Clayton Bayou
1	50	40
2	108	104
3	140	175
4	128	217
5	116	223
6	98	199
7	84	169
8	70	143
9	58	117
10	48	96
11	38	78
12	28	63
13	16	48
14	8	35
15	0	24
16		14
17		5
18		0

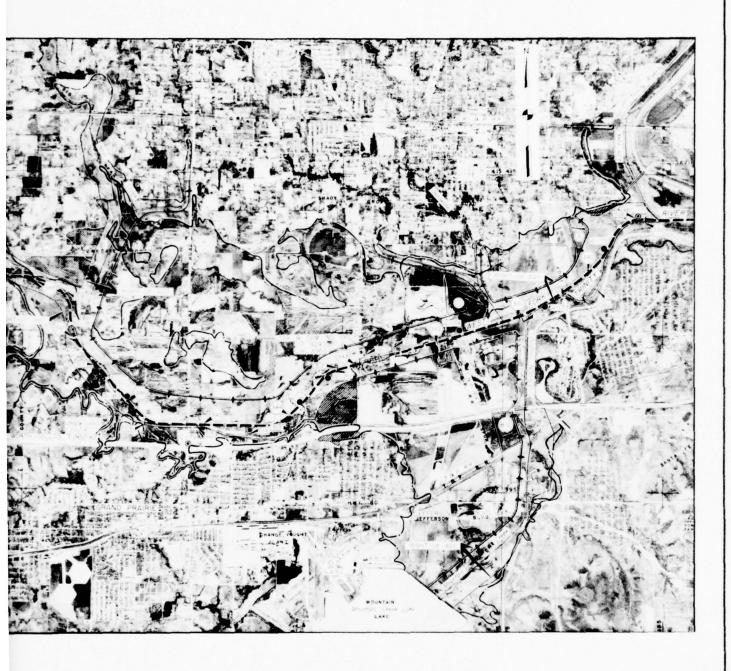




NAVIGATION AND FLOOD CONTROL CHANNEL DESIGN WATER SURFACE HIGH WATER LINE (MAXIMUM OF RECORD) NAVIGATION LOCK AND DAM RIVER MILEAGE CHANNEL MILEAGE CORE BORINGS AUGER BORINGS FILL AREA SUMP AREA

NEW EARTH LEVEES **** EXISTING LEVEES STRENGTHEN EXISTING LEVEES - (80) - (2) FEDERAL HIGHWAY STATE HIGHWAY -(35€) -INTERSTATE HIGHWAY 57 -11-

FARM TO MARKET ROAD EXISTING BRIDGE COUNTY LINE GRAVITY FLOW DRAINAGE STRUCTURE



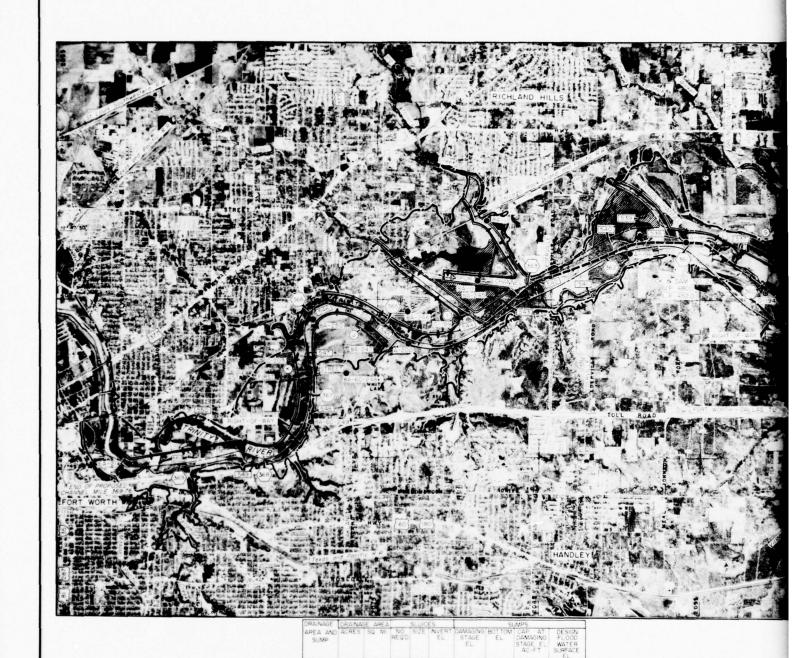
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EARTH LEVEES

ING BRIDGE
TY LINE
TY FLOW DRAINAGE STRUCTURE

WEST FORK AND TRIBUTARIES, TEXAS
WEST FORK AND TRIBUTARIES
MULTIPLE PURPOSE CHANNEL
AND FLOODWAY

LOCAL	PROTECTIO	N PROJE	CTS
IN 2 SHEETS	SCALE OF	FEET 2000 4000	SHEET NO.
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M. C. Cood	The NEW	- To to	D to aniet
to the standing	18184 N- 15C	10 4000 WPERY COM REPORT ON TRINITY	
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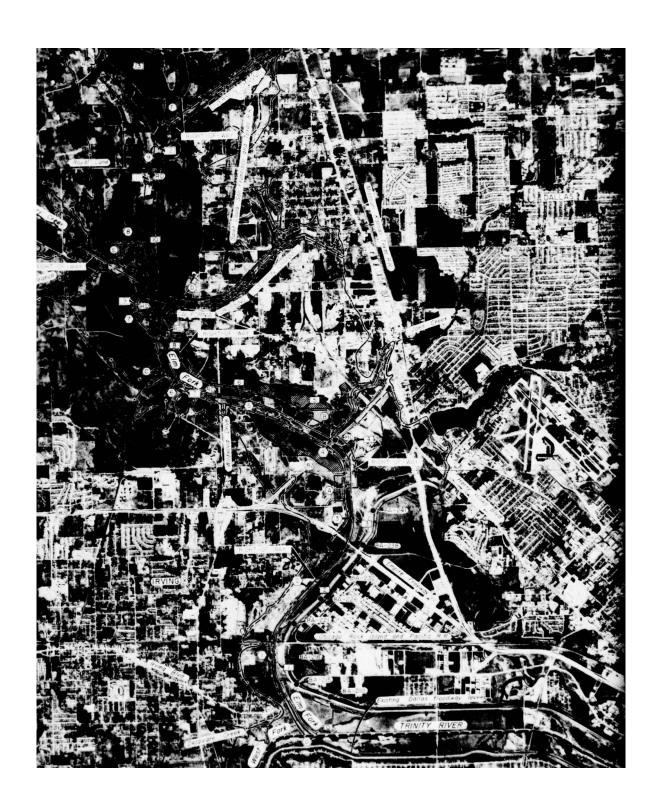


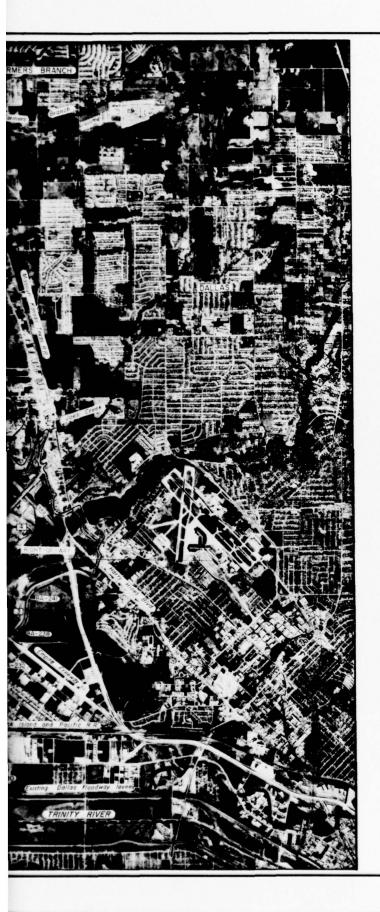
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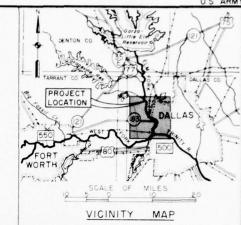
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WEST FORK AND TRIBUTARIES
MULTIPLE PURPOSE CHANNEL
AND FLOODWAY

LOCAL PROTECTION PROJECTS

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IN 2 SHEETS 2	SCALE OF	FEET 2000 4000	SHEET NO 2
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a W Wantey	DRAWN IN WEIL	TO ACCOMPANY CO.	WPREMENT SURVEY
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DRAINAGE	DRAINA	GE AREA		SLUICE	ES		SI	UMPS	
AREA AND SUMP	ACRES	SQ. MI.	NO REQ'D	SIZE	INVERT	DAMAGING STAGE EL	BOTTOM	CAP AT DAMAGING STAGE EL AC - FT	DESIGN FLOOD WATER SURFACE EL
А	905	1.41	3	5' X 5'	401	415	400	250	4142
В	2,952	4.61	6	5' X 5'	401	416	400	800	415.9
С	1,273	1.99	3	5' X 5'	405	421	404	350	421.0
D	2,381	3.72	3	6 X 6	406	423	405	650	4228
E	3,738	5.84	5	6, x 6,	408	425	407	1000	424.4
F	3,724	5.82	5	6, x e,	411	430.	410	1000	4286
G	2.720	4.25	5	5' X 5'	417	435	416	750	434.8
Н	1,700	2.66	3	6' X 6'	418	437	417	460	435.2

NAVIGATION AND FLOOD CONTROL CHANNEL DESIGN WATER SURFACE HIGH WATER LINE (MAXIMUM OF RECORD) NAVIGATION LOCK AND DAM RIVER MILEAGE CHANNEL MILEAGE CORE BORINGS AUGER BORINGS FILL AREA SUMP AREA NEW EARTH LEVEES **** EXISTING LEVEES STRENGTHEN EXISTING LEVEES - (80)-FEDERAL HIGHWAY STATE HIGHWAY (57) INTERSTATE HIGHWAY FARM TO MARKET ROAD ---EXISTING BRIDGE COUNTY LINE GRAVITY FLOW DRAINAGE STRUCTURE

TRINITY RIVER AND TRIBUTARIES, TEXAS

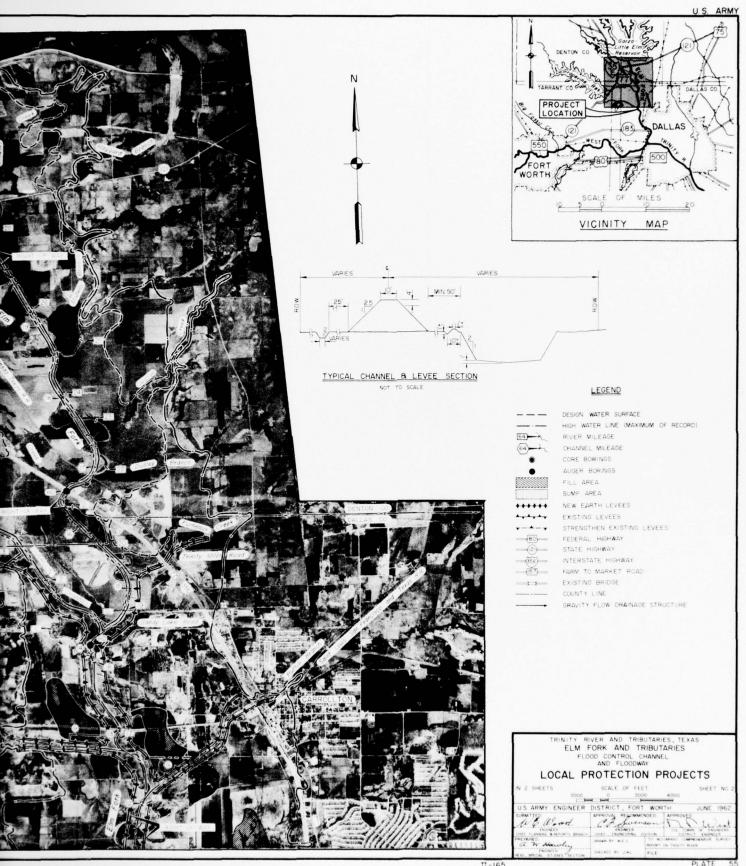
ELM FORK AND TRIBUTARIES

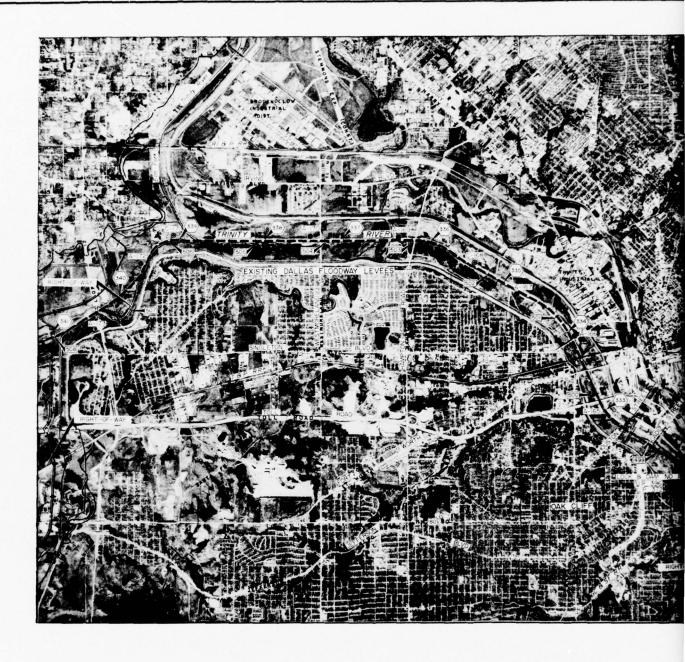
FLOOD CONTROL CHANNEL

AND FLOODWAY

LOCAL PROTECTION PROJECTS

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US ARMY ENG	INEER DISTRICT	, FORT W	ORTH	JUNE	1962
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CHEF PLANNING & REPOR	TS BRANCH, CHIEF, ENGI	MEETING DIVISION	20,	TRICT ENGIN	EER
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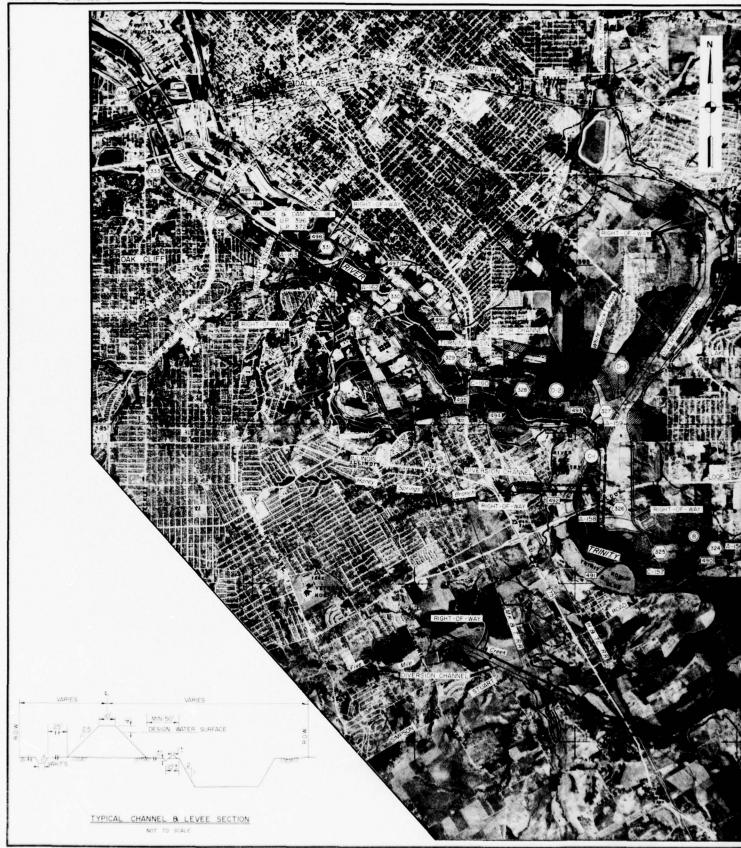
	NAVIGATION AND FLOOD CONTROL CHANNEL
	DESIGN WATER SURFACE
	HIGH WATER LINE (MAXIMUM OF RECORD)
	NAVIGATION LOCK AND DAM
64	RIVER MILEAGE
(64)	CHANNEL MILEAGE
•	CORE BOKINGS
•	AUGER BORINGS
	FILL AREA
	SUMP AREA
*****	NEW EARTH LEVEES
****	EXISTING LEVEES
	STRENGTHEN EXISTING LEVEES
(80)	FEDERAL HIGHWAY
(2)	STATE HIGHWAY
(35E)-	INTERSTATE HIGHWAY
= 157	FARM TO MARKET ROAD
-1.1-	EXISTING-BRIDGE
	COUNTY LINE
	GRAVITY FLOW DRAINAGE STRUCTURE

TRINITY RIVER AND TRIBUTARIES, TEXAS DALLAS FLOODWAY MULTIPLE PURPOSE CHANNEL

LOCAL PROTECTION PROJECTS

US ARMY ENGINEER DISTRICT, FORT WORTH

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DRAINAGE	DRAINA	SE AREA		SEUICE	S		SU	MPS .	
AREA AND SUMP	ACRES	SQMI	NO. REGID	SIZE	INVERT EL	DAMAGING STAGE EL	BOT TOM EL	CAP AT DAMAGING STAGE EL AC-FT	DESIGN FLOOD WATER SURFACE EL
Α	5,114	7.99	- 5	6' X 6'	375	385	374	2,250	385.0
В	1,376	215	3	5' X 5'	375	385	374	620	3845
	2,411	3 77	4	5' x 5'	375	390	374	1,100	369.0
C-5	535	0.84		4 x 4	375	400	374	250	3932
D-1	3,736	584	3	5' X 5'	375	390	374	1,800	389.7
0-2	1,634	2.55		5 x 5	375	390	374	800	388.0

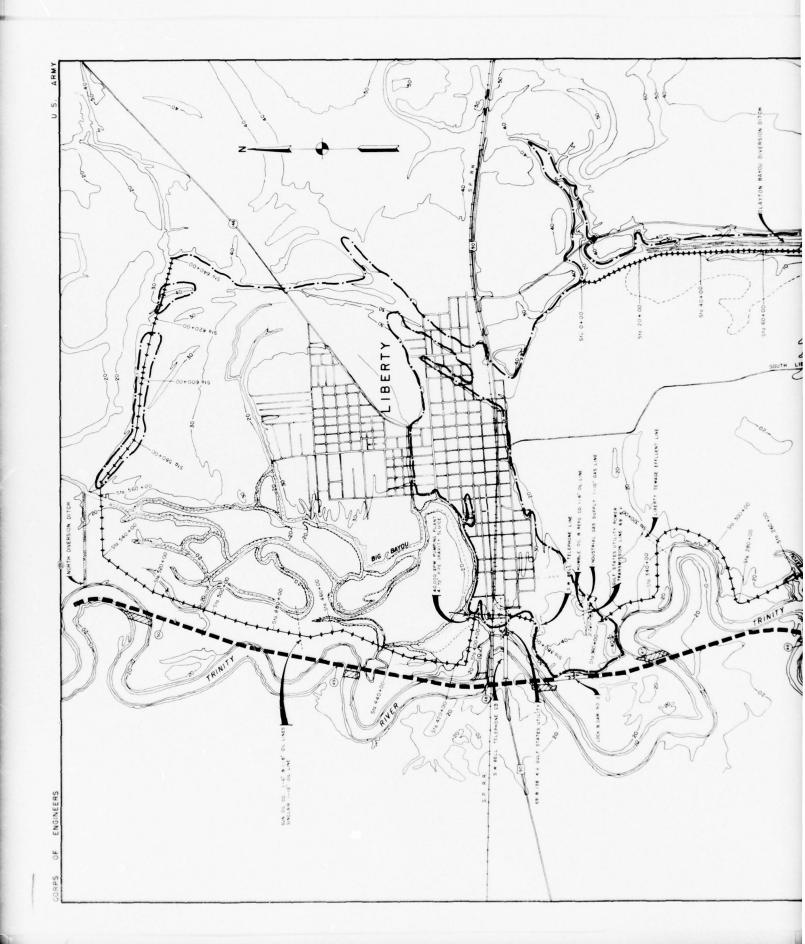
NAVIGATION AND FLOOD CONTROL CHANNEL DESIGN WATER SURFACE HIGH WATER LINE (MAXIMUM OF RECORD) 33 NAVIGATION LOCK AND DAM RIVER MILEAGE CHANNEL MILEAGE CORE BORINGS AUGER BORINGS FILL AREA SUMP AREA NEW EARTH LEVEES **** EXISTING LEVEES STRENGTHEN EXISTING LEVEES FEDERAL HIGHWAY STATE HIGHWAY -(35E)-INTERSTATE HIGHWAY (57) FARM TO MARKET ROAD EXISTING BRIDGE

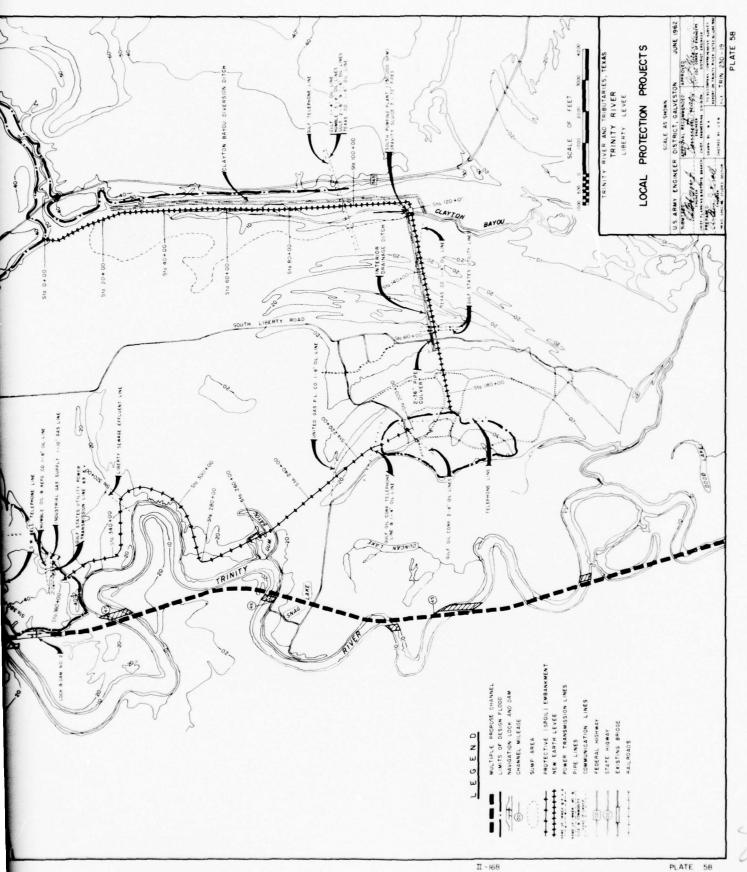
TRINITY RIVER AND TRIBUTARIES, TEXAS
DALLAS FLOODWAY EXTENSION
MULTIPLE PURPOSE CHANNEL

LOCAL PROTECTION PROJECTS

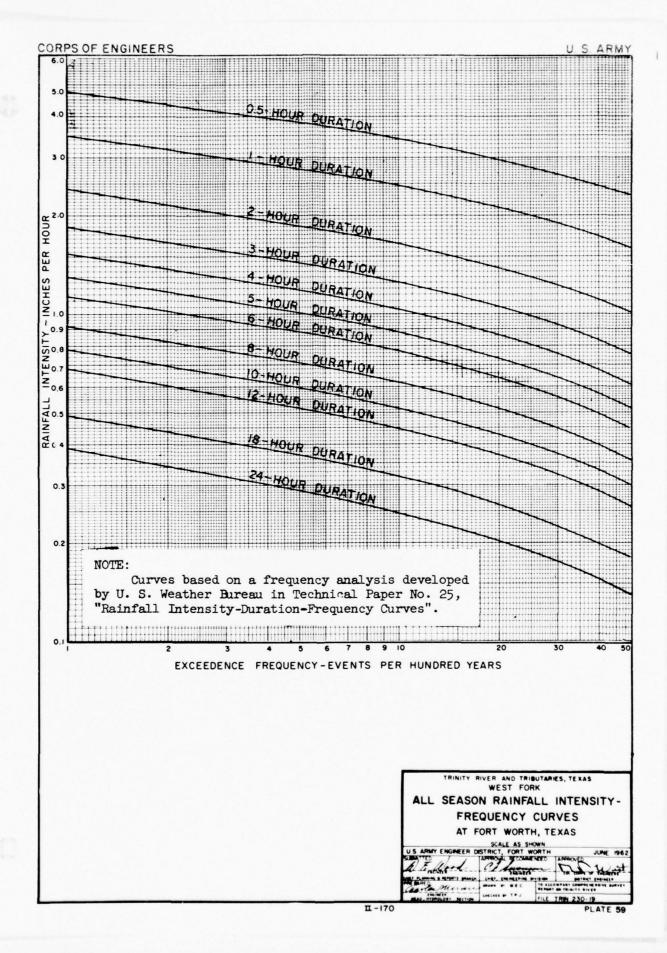
SCALE OF FEET U.S. ARMY ENGINEER DISTRICT, FORT WORTH

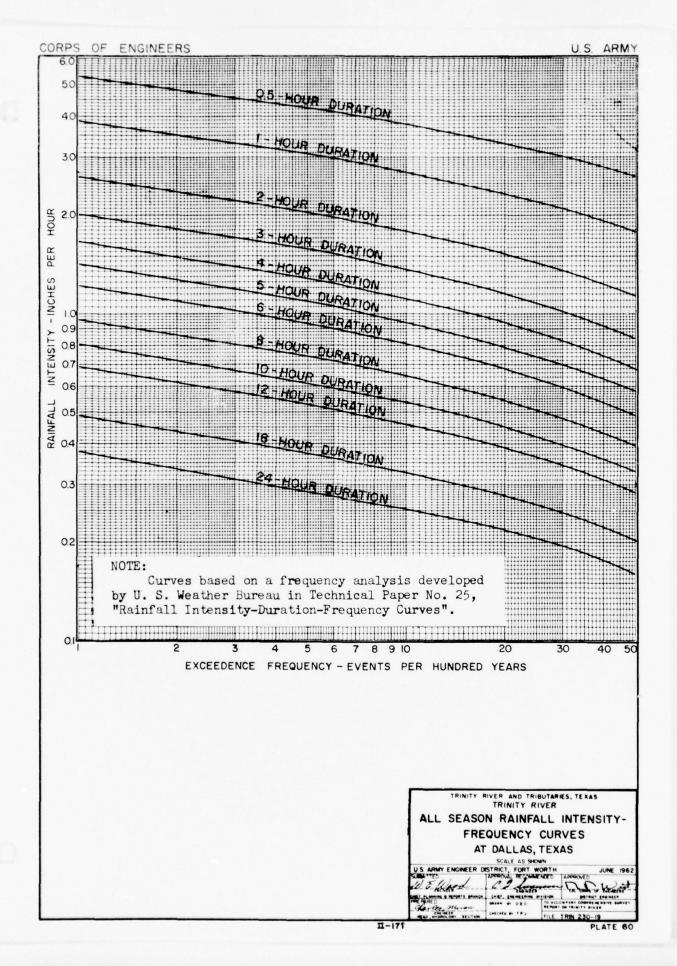
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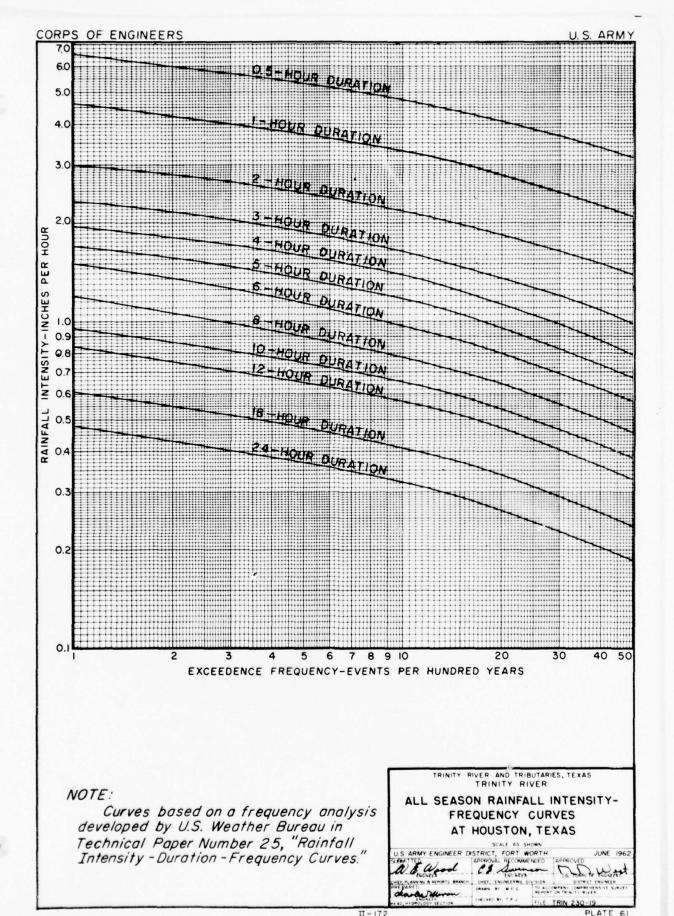




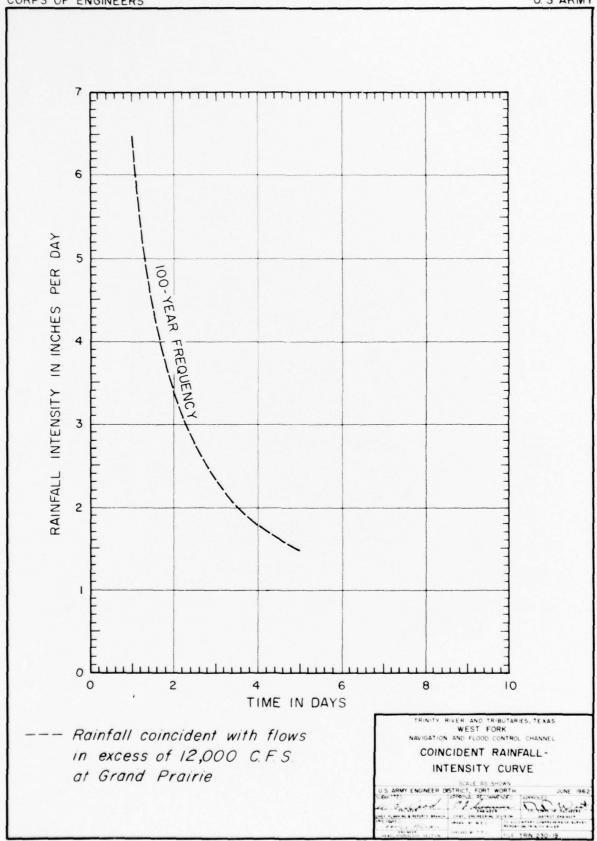
- 122. INITIAL LOSSES AND INFILTRATION INDICES INTERIOR DRAINAGE AREAS. The studies of initial losses and infiltration indices for the Upper Trinity River Basin previously discussed in paragraph 102 were used as a basis for adoption of an initial loss of 0.5 inch and an infiltration index of 0.05 inch per hour for the interior drainage areas of the West Fork and Elm Fork Floodways and the Dallas Floodway extension. An initial loss of 1.0 inch and an infiltration index of 0.10 inch per hour was adopted for the interior drainage areas for the flood protection at Liberty, Texas.
- 123. RAINFALL INTENSITY-DURATION. All-season rainfall intensity-frequency curves for durations of from one-half to twenty-four hours for the U. S. Weather Bureau first-order stations at Fort Worth, Dallas, and Houston are shown on plates 59, 60, and 61, respectively. These curves are based on a frequency analysis developed by the U. S. Weather Bureau and presented in Technical Paper No. 25, "Rainfall Intensity-Duration-Frequency Curves," (December 1955).

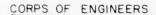




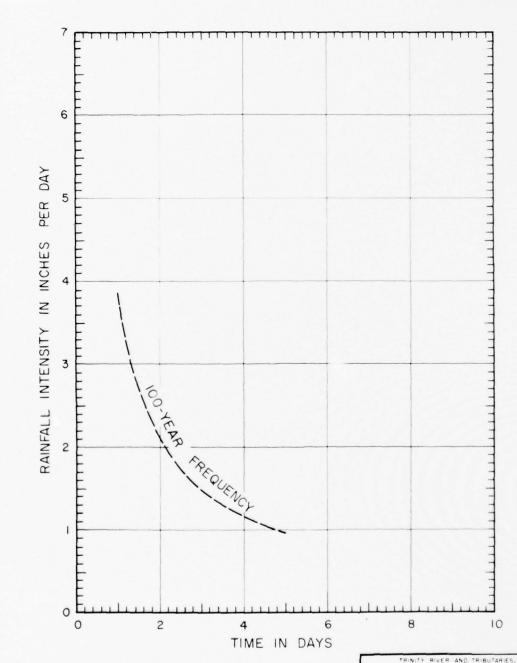


124. Rainfall intensity-frequency studies were also made to determine the rainfall of 100-year frequency that might be expected to occur coincident with river flows at or above the gate-closing stages for proposed sluices in the three floodway areas. The recommended operating discharges on the West Fork, Elm Fork, and the Trinity River at Dallas are 12,000; 12,000, and 20,000 second-feet, respectively. During the passage of major floods, these flows will be experienced within the floodways for prolonged periods of time. The inverts of the gravity sluices on the West Fork and the Trinity River at Dallas were established at or near the flow-line elevations resulting from the recommended operating discharges. In the case of the Elm Fork a discharge of 8,000 second-feet was used to establish the inverts of the gravity sluices; however, this will be adjusted during preconstruction planning stages to satisfy flow conditions for 12,000 second-feet. The stage produced by the operating discharge on each of these streams has been assumed to be the gate-closing stage for the gravity sluices. The periods when river flows were at or above the assumed gate-closing stages in each of the three floodway areas were determined from hydrographs (as modified by the existing and recommended upstream reservoirs) at Grand Prairie, Carrollton, and Dallas for the period 1924-1957. The daily increments of rainfall occurring during each of these periods of gate closure were determined from observed records at rainfall stations at or near each of the three floodway areas. Coincident rainfall intensity-frequency curves on the West Fork (Grand Prairie), the Elm Fork (Carrollton), and for the Dallas Floodway extension were then constructed from the above data in accordance with the graphical method set forth in Civil Works Engineer Bulletin 52-24, dated August 26, 1952 ("Statistical Methods in Hydrology," by Leo R. Beard). Coincident 100-year rainfall intensity curves for the West Fork and Elm Fork Floodways, and the Dallas Floodway extension are shown on plates 62, 63, and 64, respectively. Rainfall-frequency studies were also made to determine the rainfall that might be expected to occur coincident with river flows of 35,000 second-feet or more at Liberty, Texas. During the passage of major floods, flows of 35,000 second-feet or more would be experienced at Liberty for prolonged periods of time. The above discharge was, therefore, assumed to produce river stages at which the gravity drainage structures would be closed at liberty. The periods when river flows were at or above a discharge of 35,000 second-feet were determined from hydrographs (as modified by existing and recommended upstream reservoirs) at Romayor, Texas, for the period 1924-1957. No frequency analysis was made at the Liberty gage, because this gage is affected by tidal conditions. The Romayor gage is located approximately 50 river miles upstream from Liberty with only a 400-square mile reduction in drainage area; it was therefore concluded that information relative to flows at the Romayor gage was applicable at Liberty. The daily increments of rainfall occurring during each of the periods of flow of 35,000 second-feet or more were determined from records of observed rainfall at Liberty, Texas. A coincident rainfall-frequency curve for the Trinity River at Liberty was then constructed from the above data in accordance with the graphical method set forth in Civil Works Engineer Bulletin 52-24, and is shown on plate 65.





U. S. ARMY



--- Rainfall coincident with flows in excess of 8,000 C.F.S. at Carrollton. Detailed reservoir regulation studies assumed 8,000 C.F.S. operating discharge. The regulation will be made with 12,000 C.F.S. during preconstruction stage.

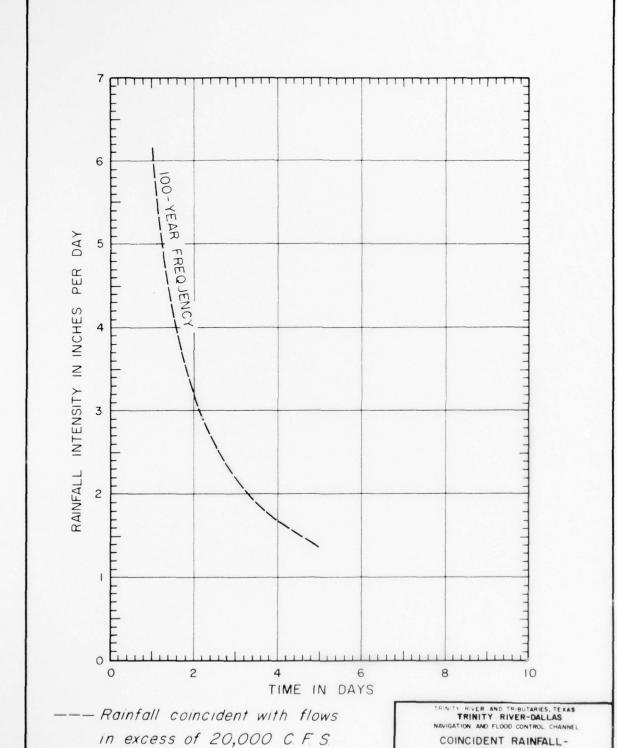
TRINITY RIVER AND TRIBUTARIES, TEXAS
ELM FORK
FLOOD CONTROL CHANNEL AND FLOODWAY
COUNCIDENT PAINEALL -

COINCIDENT RAINFALL-INTENSITY CURVE

US ARMY ENGINEER DISTRICT, FORT WORTH

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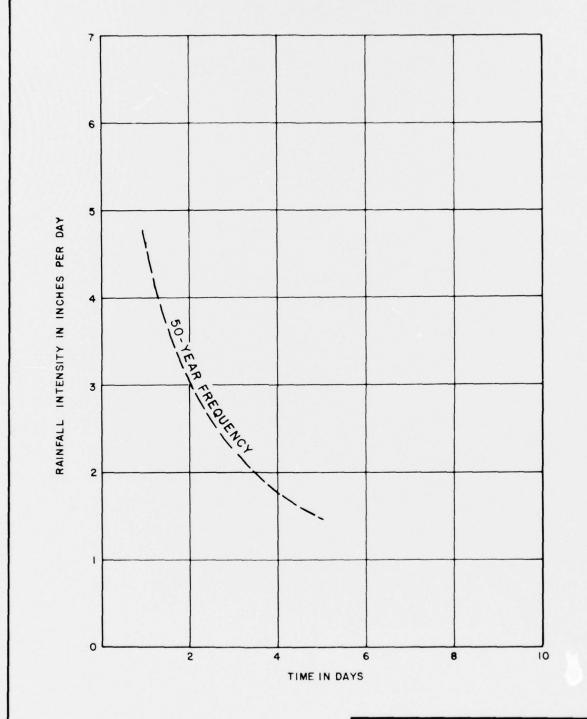
at Dallas.



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PLATE 64

INTENSITY CURVE



--- RAINFALL COINCIDENT WITH FLOWS IN EXCESS OF 35,000 C.F.S. AT LIBERTY, TEXAS.

TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER-LIBERTY
NAVIGATION AND FLOOD CONTROL CHANNEL

COINCIDENT RAINFALL-INTENSITY CURVE

125. DESIGN STORM FOR INTERIOR DRAINAGE FACILITIES. - The urban development within the areas to be protected by recommended levees on the West Fork, Elm Fork, and the Dallas Floodway extension consists principally of high-valued, concentrated, commercial or industrial facilities with some moderate to high-valued residential sections in the vicinity of the Dallas Floodway extension. The criteria for design of interior drainage facilities in urban areas are set forth in a preliminary manuscript of EM 1110-2-1410 (Engineering Manual, Civil Works Construction, Part CXIV, Chapter 10, dated August 1955, subject "Interior Drainage of Leveed Urban Areas"). In accordance with information therein, the areas to be protected would be classified as class U-1 (urban commercial). The storm resulting from a 100-year frequency rainfall has, therefore, been adopted as the design storm for proposed gravity drainage facilities on the West Fork and Elm Fork Floodways, and the Dallas Floodway extension. The future urban development anticipated within the area to be protected by the recommended levee on the Trinity River at Liberty would consist of moderate to high-valued residential areas with some commercial and industrial sections. In accordance with the criteria set forth in the above referenced engineering manual, this area would be classified as class U-2 (urban, general). Interior drainage from the leveed areas would pass through gated outlet structures in the levees during periods when gravity drainage is feasible and by pumping during periods when the flow of the Trinity River is at or above 35,000 second-feet at Liberty. The excess rainfall resulting from the 100-year frequency rainfall has been adopted as the design storm for proposed gravity drainage facilities at Liberty during periods of low flows. The excess rainfall resulting from the 50-year coincident rainfall has been adopted as the design storm for pumping facilities at Liberty during periods when flows of 35,000 second-feet or more are experienced at Liberty.

126. Plates 59 and 60 show all-season rainfall intensity-frequency curves for Fort Worth and Dallas, respectively. However, for a storm of 100-year frequency there are only minor differences between the Fort Worth and Dallas curves. Therefore, all-season rainfall of 100-year frequency has been determined utilizing the Dallas curves and adopted for the design of gravity drainage facilities at the recommended Upper Trinity River floodway projects. The incremental rainfall amounts based upon the curves of plate 60 have been arranged substantially in accordance with the criteria presented on plates 10 and 11 of EM 1110-2-1411 ("Standard Project Flood Determinations"). An initial loss of 0.50 inch and an infiltration index of 0.05 inch per hour were used in determining the rainfall-excess. The rainfall amounts at Liberty were distributed in a similar manner. The losses given in paragraph 122 were used in determining the rainfall-excess at Liberty. The 100-year all-season rainfall and rainfall-excess adopted for the design of gravity drainage facilities are shown in tables 58 and 59.

TABLE 58

DESIGN STORM RAINFALL & RAINFALL-EXCESS FOR GRAVITY DRAINAGE FACILITIES

UPPER TRINITY RIVER BASIN

100-YEAR FREQUENCY

Time in 1-hour periods	: Rainfa : (inche	Loss (inches)	0 0	Rainfall- excess (inches)	
perious	· /mone	 111011007		\	
1	0.01	0.01		0	
1 2 3 4	0.02	0.02		0	
3	0.03	0.03		0	
4	0.04	0.04		0	
	0.05	0.05		0	
5 6 7 8	0.06	0.06		0	
7	0.13	0.13		0	
8	0.14	0.14		0	
9	0.15	0.07		0.08	
10	0.16	0.05		0.11	
11	0.17	0.05		0.12	
12	0.20	0.05		0.15	
13	0.28	0.05		0.23	
14	0.64	0.05		0.59	
15	1.35	0.05		1.30	
16	3.87	0.05		3.82	
17	0.90	0.05		0.85	
18	0.35	0.05		0.30	
19	0.12	0.05		0.07	
20	0.11	0.05		0.06	
21	0.10	0.05		0.05	
22	0.09	0.05		0.04	
23	0.08	0.05		0.03	
24	0.07	0.05		0.02	
Total	9.12	1.30		7.82	

TABLE 59

DESIGN STORM RAINFALL AND RAINFALL-EXCESS
FOR GRAVITY DRAINAGE FACILITIES - LIBERTY
100-YEAR FREQUENCY

Time in 2-hour periods	:	Rainfall (inches)	:	Loss (inches)	:	Rainfall- excess (inches)
1		0.10		0.10		0
2		0.14		0.14		0
3		0.18		0.18		0
4		0.26		0.26		0
5		0.40		0.32		0.08
5		0.62		0.20		0.42
7		1.80		0.20		1.60
8		6.00		0.20		5.80
9		1.00		0.20		0.80
10		0.50		0.20		0.30
11		0.30		0.20		0.10
12		0.22		0.20		0.02
Total		11.52		2.40		9.12

127. DESIGN FLOOD CRITERIA FOR INTERIOR DRAINAGE FACILITIES.—
The interior drainage areas that will be created by construction of
the recommended levees are shown on plates 52 through 58. The design
flood hydrograph for gravity drainage of each interior drainage area
was obtained by applying the rainfall-excess values shown in tables
58 and 59 to the appropriate unit hydrograph for each area shown
in tables 54 through 57.

128. Gate-closing stage for each interior drainage area was established as set forth in paragraph 124. Sufficient sump storage has been provided in each interior drainage area of recommended floodways on the Upper Trinity River Basin to store the runoff resulting from the 100-year frequency storm rainfall that would occur coincident with the gate-closing stages on the individual streams without exceeding the damaging stage in each sump area. The capacity of the proposed sumps was established as follows: The coincident rainfall intensity curves described in paragraph 124 and shown on plates 62, 63, and 64 were used to determine the 100-year storm rainfall, which was then arranged substantially in accordance with the criteria presented on plates 10 and 11 of EM 1110-2-1411. Application of an infiltration rate of 0.05 inch per hour to the storm rainfall produced runoff within the interior

drainage areas of the West Fork and Elm Fork Floodways and Dallas Floodway extension of 5.61; 3.14; and 5.18 inches, respectively. Sufficient sump and pump capacity has been provided in the Big Bayou and Clayton Bayou interior drainage areas of the Liberty project to handle the runoff resulting from the 50-year storm rainfall that would occur coincident with gate-closing stages without exceeding the damaging stages within the two sump areas. The coincident rainfall intensity curve shown on plate 65 was used to determine the 50-year storm rainfall and an arrangement was adopted similar to that used for the Upper Trinity River local protection projects. Application of an infiltration rate of 0.10 inch per hour to the storm rainfall produced runoff of 3.75 inches.

129. Utilizing the sump and pump capacities established by the methods set forth in the preceding paragraph, each gravity sluice was then sized to pass the design flood hydrograph resulting from 100-year all-season rainfall (see paragraph 125) with free discharge at the outfall without exceeding the minimum damaging stage within the sump areas. Tables 60 through 63 summarize pertinent data for each interior drainage area on the West Fork, Elm Fork, Dallas Floodway extension, and at Liberty, respectively.

TABLE 60
WEST FORK INTERIOR DRAINAGE AREAS - PERTINENT DATA

	:	: Recon	mended	: Recomm	nended sum	p
	:	: gravity	sluices		:	:Capacity
	:Drainage	:	:Number		•	: at
Area	: area	: Invert	: and	: Bottom	:Damaging	:damagin
designation		<pre>:elevation :(ft-msl)</pre>		<pre>:elevation :(ft-msl)</pre>		: stage :(ac-ft)
Α	1.35	399.0	1-5x5	398.0	415.0	450
B-1	1.05	399.0	1-4x4	398.0	422.0	350
B-2	3.62	401.0	1-6x6	400.0	422.0	1,150
C	7.81	399.0	2-6x6	398.0	426.0	2,350
D	3.55	427.0	1-6x6	426.0	456.0	1,100
E	2.33	455.0	1-5x5	454.0	477.0	750
F	3.05	455.0	1-6x6	454.0	474.0	1,000
G	1.84	455.0	1-4x4	454.0	478.0	600
H	1.73	483.0	1-6x6	482.0	495.0	550
I	2.07	483.0	1-6x6	482.0	500.0	650
J	0.77	483.0	1-4x4	482.0	500.0	250
K	2.29	483.0	1-5x5	482.0	505.0	700

TABLE 61

ELM FORK INTERIOR DRAINAGE AREAS - PERTINENT DATA

	:	: Recomm	nended	: Reco	mmended su	mp
	:	: gravity	sluices	_:	:	:Capacity
Area	:Drainage	:	:Number	:	:	: at
designation	: area	: Invert	: and	: Bottom	:Damaging	:damaging
	:(square	:elevation		:elevation		: stage
	: miles)	:(ft-msl)	:(feet)	:(ft-msl)	:(ft-msl)	:(ac-ft)
A	1.41	401.0	3-5×5	400.0	415.0	250
В	4.61	401.0	6-5x5	400.0	416.0	800
c	1.99	405.0	3-5x5	404.0	421.0	350
D	3.72	406.0	3-6x6	405.0	423.0	650
E	5.84	408.0	5-6x6	407.0	425.0	1,000
F	5.82	411.0	5-6x6	410.0	430.0	1,000
G	4.25	417.0	5-5x5	416.0	435.0	750
H	2.66	418.0	3-6x6	417.0	437.0	460

TABLE 62

DALLAS FLOODWAY EXTENSION
INTERIOR DRAINAGE AREAS - PERTINENT DATA

:					ump
•	gravity	sluices	_:	:	:Capacity
:Drainage	:	:Number	:	:	: at
: area	: Invert	: and	: Bottom	:Damaging	:damaging
:(square	:elevation	: size	:elevation	n: stage	: stage
: miles)	:(ft-msl)	:(feet)	:(ft-msl)	:(ft-msl)	:(ac-ft)
		ALLEN COLLEGE MAIN COLLEGE			*
7.99	375.0	5 - 6x6	374.0	385.0	2,250
2.15	375.0	3-5x5	374.0	385.0	620
3.77	375.0	4-5x5	374.0	390.0	1,100
0.84	375.0	1-4x4	374.0	400.0	250
5.84	375.0	3-5x5	374.0	390.0	1,800
2.55	375.0	1-5x5	374.0	390.0	800
	rea (square miles) 7.99 2.15 3.77 0.84 5.84	rea : Invert (square :elevation miles) :(ft-msl) 7.99 375.0 2.15 375.0 3.77 375.0 0.84 375.0 5.84 375.0	: area : Invert : and :(square :elevation: size : miles) :(ft-ms1) :(feet) 7.99 375.0 5-6x6 2.15 375.0 3-5x5 3.77 375.0 4-5x5 0.84 375.0 1-4x4 5.84 375.0 3-5x5	### area : Invert : and : Bottom : (square :elevation: size :elevation: miles) :(ft-msl) :(feet) :(ft-msl) 7.99 375.0 5-6x6 374.0 2.15 375.0 3-5x5 374.0 3.77 375.0 4-5x5 374.0 0.84 375.0 1-4x4 374.0 5.84 375.0 3-5x5 374.0	### area : Invert : and : Bottom : Damaging :(square :elevation: size :elevation: stage : miles) :(ft-msl) :(feet) :(ft-msl) :(ft-msl) :(ft-msl) : 7.99

TABLE 63

LIBERTY INTERIOR DRAINAGE AREAS - PERTINENT DATA

	:	: Recomme	ended	:	:Recommen	
	:	: gravity	sluices	:		Capacity
Area	:Drainage		:Number	:Recommended	l: :	at
designation	ı: area	: Invert	: and	: pumping	:Maximum:	maximum
		:elevation		: capacity	: stage :	
	: miles)	:(ft-msl)	:(feet)		:(ft-msl):	(ac-ft)
Big Bayou	3.07	12.6	4 - 6	40,000	18.6	400
Clayton Bay	5.43	5.3	7 - 6	150,000	11.3	290

CHANNELS

- 130. GENERAL.- Three basic requirements must be met in the design of the channels on the Trinity River and tributaries. These requirements are navigation, reservoir regulation, and flood control. A channel for navigation would be of sufficient depth and width to accommodate the modern barge navigation required to transport the prospective commerce on the canal. Channels for reservoir regulation purposes would be of sufficient capacity to pass such reservoir releases as were necessary to accomplish evacuation of the flood-control storages in upstream reservoirs within a 30 to 40-day period. The objective with regard to flood control for agricultural areas would be, when economically feasible, to provide 50-year protection against floods originating on the uncontrolled areas below upstream reservoirs.
- 131. Channel capacities on the Trinity River below Dallas vary from about 9,000 second-feet in the vicinity of Rosser, up to 53,000 second-feet in the vicinity of Riverside, and then down to 20,000 second-feet in the vicinity of Liberty. Under present conditions of watershed development, with the existing reservoirs in operation, flows at or above bankfull capacity originating from runoff on the uncontrolled area are experienced on an average of once a year at Rosser and Liberty, and once about every 4 years at Riverside. Each year the operation of flood-control reservoirs in the Upper Trinity River Basin points up the deficiency of channel capacity prevalent in streams below the reservoirs. As a result of this channel deficiency, flooding is frequently produced by the occurrence of storms over the uncontrolled area and regulated flood releases from the reservoirs must be reduced or stopped entirely in order to keep flooding at a minimum. Thus, the effectiveness of the flood-control storage in upstream reservoirs is seriously impaired. The problems of flood control and reservoir regulation have been magnified by increased economic development in the flood plains. In addition to damages produced directly by overflow . from the Trinity River, serious losses in numerous levee districts are sustained from interior flooding attributable to the inability of drainage structures to discharge local runoff into the river during high stages. Further details of these problems and the requirements necessary for their correction are set forth in the following paragraphs.
- 132. NAVIGATION CHANNEL. Channel-size formulation studies for navigation show that a channel having a depth of 12 feet and a bottom width of 150 feet would be the most economical for modern barge navigation required to transport the prospective commerce on the canal. However, the conveyance capacity of such a navigation channel would be inadequate to appreciably reduce the water surface elevation of the Trinity River during major floods and, therefore, would not alleviate flooding in the problem areas. Also, the limited conveyance capacity

of the navigation channel would not be of sufficient capacity for the anticipated operating discharges required to evacuate the flood-control storages of the multi-purpose reservoir system within a reasonable period after a major flood. Since channel requirements for flood control and reservoir regulation generally exceed the requirements for the navigation channel, no further consideration has been given to the requirements for navigation only.

- 133. CHANNEL REQUIREMENTS FOR RESERVOIR REGULATION.- In establishing channel capacities for reservoir regulation purposes, consideration was given to the period required for the evacuation of flood-control storages from upstream reservoirs. The retention of flood-storage accumulations in the reservoirs reduces their ability to control succeeding floods. Consequently, an increase in downstream channel capacities would make higher releases possible, would reduce the emptying time, and thus provide a more effective utilization of the flood-control capacity in the reservoirs. An emptying time of from 30 to 40 days is considered desirable for reservoirs in the Trinity River Basin.
- 134. A channel deficiency presently exists on the East Fork where the capacity is only 500 to 1,200 second-feet, although under the present plan for Lavon Reservoir, regulation is made to 2,000 second-feet on the East Fork downstream from the dam. However, a channel capacity of 5,000 second-feet has been recommended in the "Review of Reports on Trinity River and Tributaries, Texas, Covering the East Fork Watershed," dated November 1, 1961. Another critical area is on the Trinity River in the vicinity of Rosser where the existing channel capacity is only 9,000 second-feet. Under the present plan of regulation for the Upper Trinity River reservoirs, regulation is to 13,000 second-feet at Dallas and this discharge, when combined with the previously recommended 5,000 second-feet on the East Fork, would produce a regulated flow of 18,000 second-feet at Rosser. Under the plan of improvement set forth in this report, the recommended Lakeview Reservoir would contribute an additional 4,000 second-feet, thereby increasing the regulation at Dallas and Rosser to 17,000 and 22,000 second-feet, respectively. On the Trinity River below the recommended Tennessee Colony Reservoir the minimum bankfull capacity is 20,000 second-feet in the vicinity of Liberty.
- 135. During flood periods releases from the Corps of Engineers reservoirs will be augmented by releases from local interest reservoirs and by uncontrolled releases from Soil Conservation Service reservoirs. Among local interest reservoirs, the system of reservoirs on the West Fork above Fort Worth will probably make the largest contribution. During the 1957 floods Lake Worth spilled for over 2 months

with the daily spills averaging about 5,000 second-feet. Investigations based upon preliminary data indicate that the combined releases from existing and proposed Soil Conservation Service reservoirs on the West Fork of the Trinity River upstream from Dallas will be about 2,000 second-feet with an additional contribution of about 3,000 second-feet between Dallas and Rosser. A similar investigation of the area below Tennessee Colony Reservoir indicates that combined releases from Soil Conservation Service reservoirs in this area will amount to about 4,000 second-feet plus an additional spill from the long-range water supply reservoirs of about 6,000 second-feet.

- 136. As set forth in paragraph 134, the present operating discharges at Dallas and Rosser, when corrected for releases from the recommended Lakeview and enlarged Lavon Reservoirs, would increase the regulation at Dallas and Rosser to 17,000 and 22,000 second-feet. respectively. Further increase in the channel capacities by 7,000 second-feet at Dallas and 10,000 second-feet at Rosser would provide additional capacity for releases from other reservoirs, as set forth in paragraph 135. The required channel capacities for reservoir regulation would then be 24,000 and 32,000 second-feet at Dallas and Rosser, respectively. A channel capacity of about 35,000 second-feet would be required below Tennessee Colony Reservoir for flood-control releases from that reservoir. The additional contribution of 4,000 second-feet from downstream Soil Conservation Service reservoirs plus the 6,000 second-feet from the long-range water supply reservoirs (see paragraph 135) would bring the total channel capacity required for reservoir regulation on the Lower Trinity River to 45,000 second-feet.
- 137. Based on the data presented in paragraphs 133 through 136, it is concluded that the channel capacities shown in table 64 would meet the combined requirements for reservoir regulation. The existing channel capacities and the recommended operating discharges are also shown in table 64. Flood routing studies made for this report were based on a regulation to only 8,000 second-feet (existing channel capacity) on the Elm Fork at Carrollton. The recommended channel capacity was subsequently increased to 15,000 second-feet with a recommended operating discharge of 12,000 second-feet at Carrollton. Since the operating discharge of 20,000 second-feet at Dallas would not be changed, the principal effect of the additional channel capacity on the Elm Fork would be to provide for an increase in flood releases from the reservoirs on the Elm Fork watershed and a reduction in those from Benbrook and Lakeview Reservoirs on the West Fork watershed. Such a regulation would generally affect only the recession side of the modified hydrographs downstream and would have little, if any, effect on modified peak discharges below the reservoirs. For this reason, further routings are not considered necessary for the purposes of this report.

TABLE 64
CHANNEL REQUIREMENTS FOR RESERVOIR REGULATION

Reach	:Average min. : :bankfull capa- :city-existing: : (cfs) :	channel	: Recommended : operating : discharge : (cfs)
Clear Fork Trinity	8,000	8,000	6,000
West Fork Trinity			
Fort Worth to mouth of Elm F	ork 7,000	15,000	12,000
Mountain Creek			
Lakeview Damsite to mouth	4,000	4,000	4,000
Elm Fork Trinity			
Denton Cr, Grapevine Dam to	mouth 6,000	7,000	6,000
Elm Fork, Lewisville Dam to			
Carrollton Gage	8,000	10,000	8,000
Carrollton Gage to mouth of		15 000	10 000(1)
Fork	8,000	15,000	12,000(1)
Trinity River	12 000	25 000	20,000
Dallas Gage East Fork Trinity	13,000	25,000	20,000
Forney Damsite to mouth	500-1,200	5,000	5,000
Trinity River	700-1,200),000	,,000
Rosser Gage	9,000	32,000	25,000
Richland Creek	,,,,,,,	52,000	-/,
Navarro Mills Dam to mouth	3,000	3,000	3,000
Chambers Creek			
Waxahachie Creek to mouth	4,000	4,000	4,000
Waxahachie Creek			
Bardwell Damsite to mouth	2,000	2,000	2,000
Trinity River	-1	1	
Oakwood Gage	24,000	45,000(2)	-,,
Liberty Gage	20,000	45,000	35,000

(1) Operating discharge of 8,000 second-feet used in flood-routing studies for this report.

(2) The proposed SCS plan of development does not provide for retardation structures on the Trinity River Basin below Romayor. Therefore, the full effect of combined releases from reservoirs in the SCS plan and the long-range water supply reservoirs would be experienced only in the reach of the river from Romayor to the mouth. This report recommends a channel capacity of 45,000 second-feet for reservoir regulation purposes in all reaches of the Trinity River below Tennessee Colony Damsite. However, in preconstruction planning studies, consideration will be given to varying the channel capacity from 45,000 second-feet in the vicinity of Romayor to about 35,000 second-feet immediately below Tennessee Colony Damsite.

138. The time required for the evacuation of the flood-control storage of the reservoirs in the recommended plan, based upon the recommended operating discharges of table 64, are shown in table 65.

TABLE 65
TIME REQUIRED FOR EVACUATION OF FLOOD-CONTROL STORAGE

Reservoir	: F1	.ood-control storage (ac-ft)	• • • • •		: Time required :for evacuation :of flood-control : storage (days)
Benbrook Lakeview Roanoke Grapevine Aubrey Garza-Little Elm		76,550(1) 136,700 223,700 47,300 258,300 331,600) -	6,000 4,000 - 12,000	7 18
r	otal	860,900		12,000	37
Lavon (enlarged) Tennessee Colony	2	275,600 2,144,300		5,000 35,000	28 31

⁽¹⁾ Flood-control storage below uncontrolled notch (elevation 710.0).

^{139.} CHANNEL REQUIREMENTS FOR FLOOD CONTROL.- The objective with regard to the design of flood-control channels for agricultural areas in this report is to provide 50-year protection against floods originating on the uncontrolled area below upstream reservoirs, when economically feasible. The average minimum bankfull capacity of existing channels and the channel capacities required (in conjunction with the recommended reservoirs) to give varying degrees of flood protection to problem areas on the Trinity River and tributaries are given in table 66.

TABLE 66
CHANNEL REQUIREMENTS FOR FLOOD CONTROL

Reach :	Average mini mum bankfull capacity of existing	: required : agai : 10-year :	to provide nst flood 25-year:	protection of 50-year
:	channel (cfs):frequency:	frequency:	frequency
Elm Fork, Lewisville Dam				
to Carrollton	8,000	8,200	13,200	18,100
Denton Creek below				
Grapevine Dam	6,000	4,600	7,000	9,000
Trinity River, Five Mile				
Creek to head of				
Tennessee Colony Reservoi:	9,000	36,000	50,000	61,000
Trinity River below Tennesse	ee			
Colony Damsite (2)	20,000	31,500	39,300	43,000

- (1) In conjunction with recommended reservoirs.
- (2) Most critical area in vicinity of Liberty.

140. MULTIPLE-PURPOSE CHANNEL REQUIREMENTS. - After due consideration of the channel requirements for navigation, reservoir regulation, and flood-control purposes presented in the preceding paragraphs, it was concluded that the channel requirements for reservoir regulation, shown in table 64, would be adopted as the basis for design of the multiple-purpose channel. Further studies for the multiple-purpose channel revealed that realignment of the channel required for navigation should be made in certain reaches of the river in order to provide improved conveyance of flood flows.

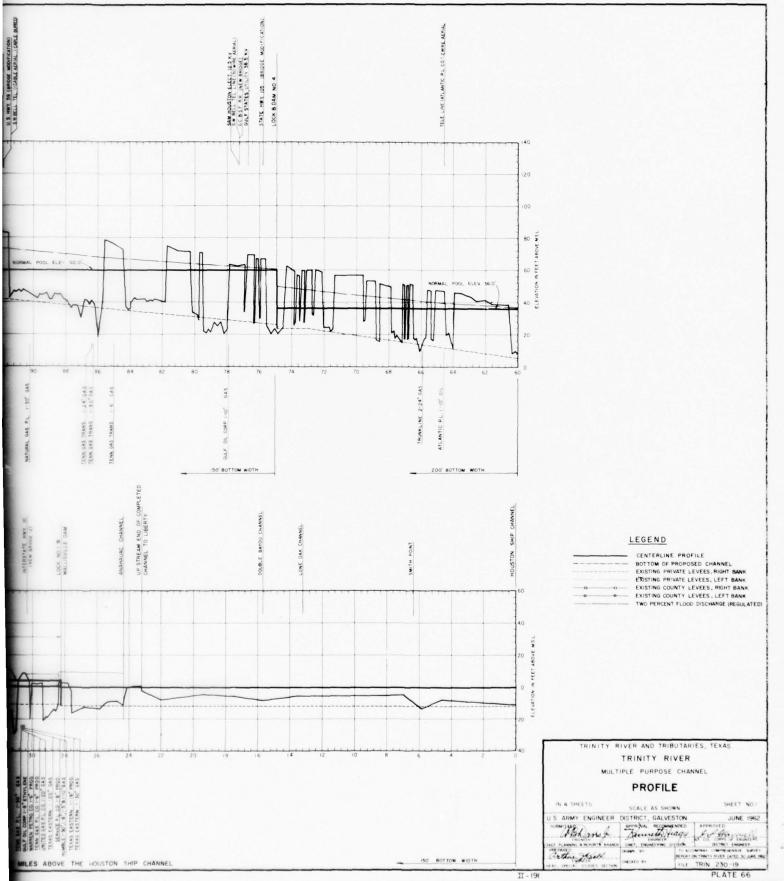
141. Generally, the channel requirements for reservoir regulation control in establishing the capacity of the multiple-purpose channel. However, greater channel capacities would be required for flood control rather than reservoir regulation purposes in the following reaches: the Elm Fork between Lewisville Dam and Carrollton, Denton Creek below Grapevine Dam, and the Trinity River between Five Mile Creek and the head of Tennessee Colony Reservoir. Consideration was given to affording greater flood protection to these areas by providing for additional channel enlargement or levees, but such a plan could not be economically justified. The recommended channel would provide for draining of leveed areas while flood-control releases from upstream reservoirs would be in progress and would afford varying degrees of protection against flooding which would result from storms originating on the uncontrolled area below the upstream Reservoirs. Table 67 shows the degree of flood

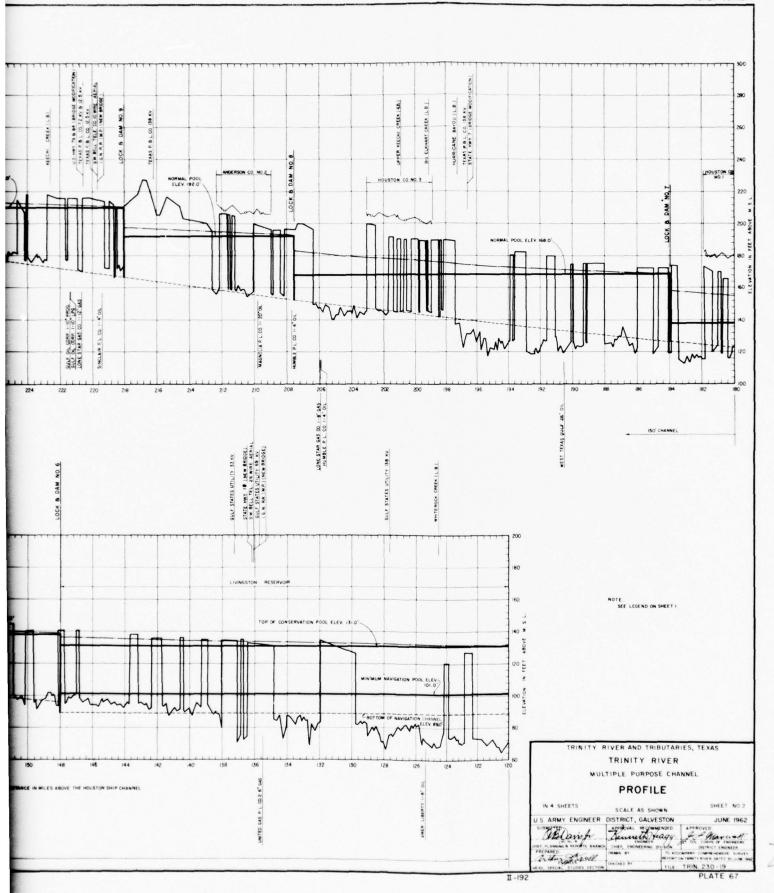
protection presently afforded to agricultural areas on the Trinity River and tributaries by the existing channel and reservoirs, and the degree of protection that would be provided by the recommended multiple-purpose channel and reservoirs. Plates 66 through 69 show the Trinity River multiple-purpose channel profiles.

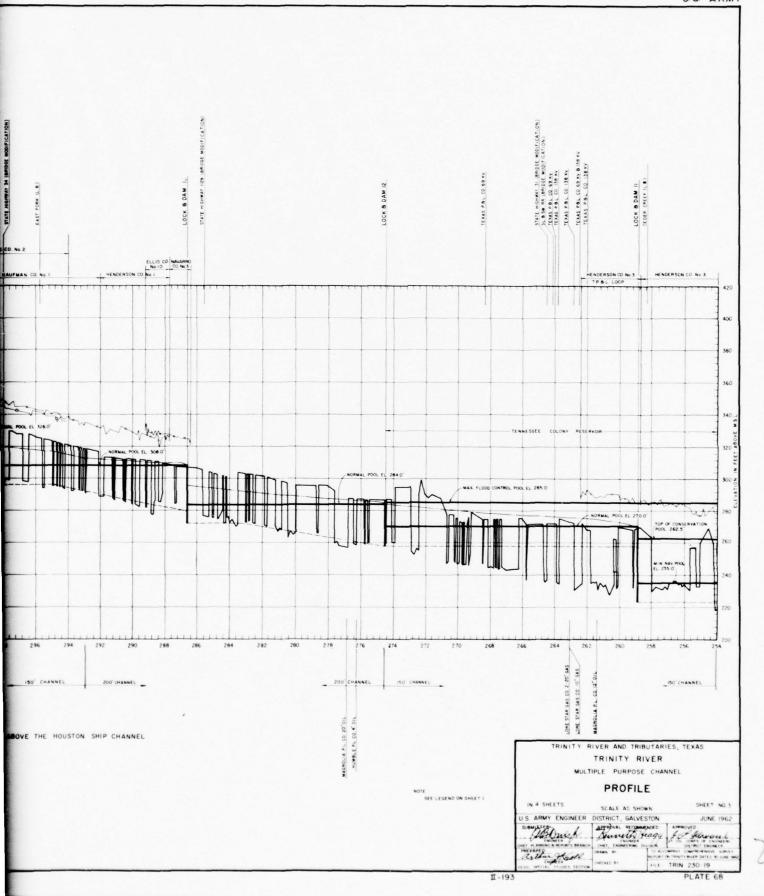
TABLE 67

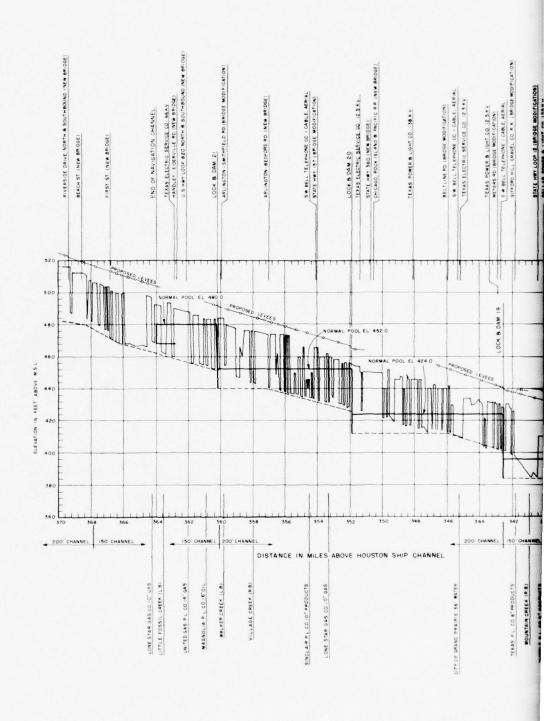
DEGREE OF PROTECTION UNDER EXISTING CONDITIONS
AND RECOMMENDED PLAN

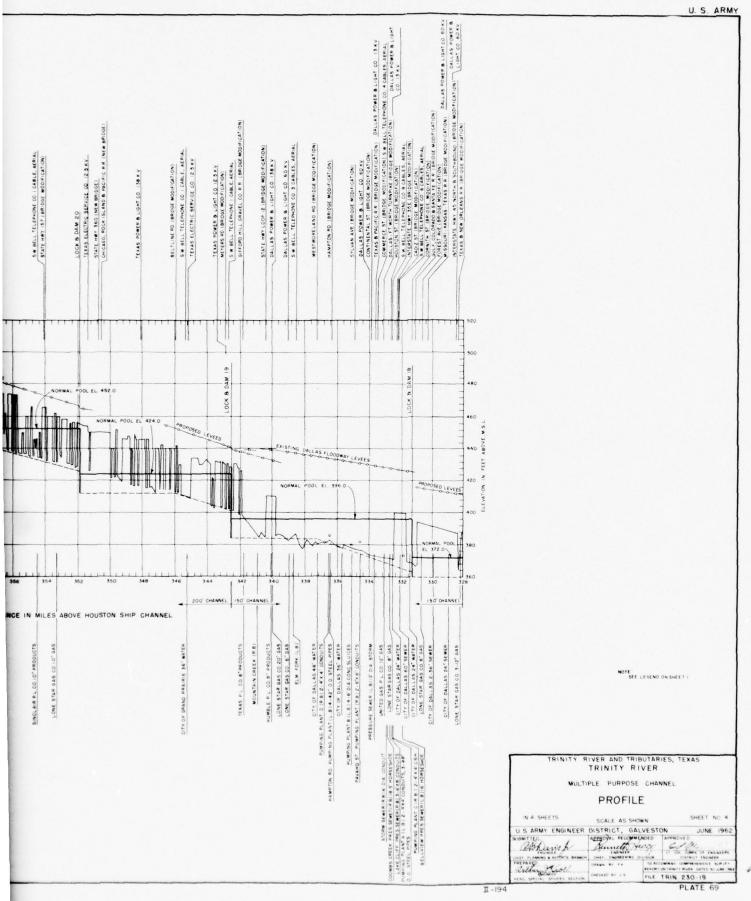
		conditions		
Reach	:minimum :f :channel :a :capacity:r	el capacit;	r: :Channel y:capacity	:Frequency of :floods at or :above channel : capacity : (years)
Elm Fork, Lewisville Dam to Carrollton	8,000	9	10,000	14
Denton Creek below Grapevine Dam	6,000	17	7,000	25
Trinity River Five Mile Creek to head of Tennessee Colony Reservoir	9,000	1	32,000	8
Tennessee Colony Damsite to river mile 313.4	24,000	l	45,000	90
River mile 313.4 to river mile 207.9	34,000	3	45,000	80
River mile 207.9 to river mile 96.4	53,000	14	45,000	70
River mile 96.4 to mouth of Trinity River	20,000	ı	45,000	60











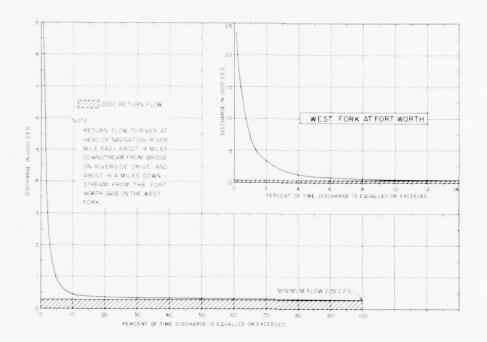
- 142. INTERIOR DRAINAGE EXISTING LEVEE DISTRICTS. There are 16 operating levee districts adjacent to the Trinity River below Dallas. Pertinent data on these levee districts are presented in table 5. River discharges which would prevent operation of the gravity sluices in each of the levee districts were determined from discharge-frequency data at gages in the vicinity of the levee districts. Based on these studies, it was estimated that drainage through the gravity sluices would be blocked at each of the levee districts at least once a year under existing conditions.
- 143. Similar studies were made assuming the recommended multiplepurpose channel and recommended reservoirs in operation. With the recommended plan of development on the basin, it was found that several of the gravity sluices would be permanently blocked by the water impounded in the navigation pools. The levee districts thus affected would be as follows: Kaufman County No. 4; Dallas County No. 1; Dallas County No. 2; Ellis County No. 2; Kaufman County No. 1; Henderson County No. 1; Navarro County No. 3; Ellis County No. 10; and Houston County No. 2. In addition, the gravity sluice of the Henderson County District No. 3 would be below the operating level of Tennessee Colony Reservoir and would be blocked. Gravity sluices in the remaining levee districts above Tennessee Colony Reservoir would be provided with about 10-year protection against blocking at the recommended operating discharges in the channel. In the remaining levee districts below Tennessee Colony Reservoir, 40- to 50-year protection would be provided against the blocking of gravity sluices at the recommended operating discharges. Under the recommended plan of improvement, these levee districts which would be permanently blocked by the navigation pools would be provided with pumping facilities to evacuate floodwater from their interior areas.
- 144. SEDIMENT IN MULTI-FURPOSE CHANNEL. The flow of the West Fork and the Trinity River from Fort Worth downstream will pass through the system of locks and dams recommended for the multiple-purpose channel. Under full development of the water resources these flows would be largely contained within the canalized multi-purpose channel consisting of a system of navigation pools formed by movable dams in the channel and in the Tennessee Colony, Livingston, and Wallisville Reservoirs. The sediment that will enter the proposed multiplepurpose channel will come from various sources. Some sediment will pass through upstream reservoirs. However, most of it would be contributed by uncontrolled drainage areas. An appreciable amount of sediment inflow would also originate as a result of propeller wash causing bank erosion or from bank slides occurring in the deeply entrenched channel sections. Sediment inflow from upstream reservoirs and from uncontrolled areas was determined as set forth in paragraph 90. Quantities of sediment inflow due to bank erosion or slides cannot be determined accurately; however, it is recognized that these may add up to considerable yardage.

145. SEDIMENT DEPOSITION .- Flows in the recommended multiplepurpose channel would exceed bankfull capacities only on rare occasions. Inspection of tables 69 and 70 indicates that the operating discharges of the multiple-purpose channel would be equalled or exceeded only about 0.8 percent of the time upstream from Livingston Dam (Pool No. 5B) and 2.7 percent of the time downstream therefrom. The additional within bank capacity that would be available between the operating discharge and the recommended minimum channel capacities would result in even shorter durations. Consequently, only a minimum amount of sediment deposition would occur outside the channel. In the case of the reach above Lock and Dam No. 12, in Tennessee Colony Reservoir, it was assumed for the purpose of this study, that about 25 percent of the total sediment load produced in each reach between locks of the multiple-purpose channel would be deposited in the channel and that the remaining 75 percent of the sediment would be transported downstream. Total sediment inflow estimated above Lock and Dam No. 12 is 1,700 acre-feet per annum, of Which 425 acre-feet per annum would be deposited in the channel and 1,275 acrefeet per annum would flow into Tennessee Colony Reservoir. An additional amount of sediment roughly estimated to equal at least 25 percent of the anticipated annual sediment yield (425 acre-feet per annum) would also be deposited in the channel as a result of bank erosion, slides, and propeller wash. It was assumed that about half of the total sediment deposited in the channel (425 acre-feet per annum) would be picked up during floods and while regulated releases are in progress and transported within the channel to be deposited in Tennessee Colony Reservoir. Thus, the resulting total sediment inflow above Lock and Dam No. 12 would be 1,700 acre-feet per annum. It was further assumed that about half of the total sediment brought in above Lock and Dam No. 12 (850 acre-feet per annum) would be deposited in the channel in Tennessee Colony Reservoir and the other half would be distributed elsewhere in the reservoir. The material deposited in the channel and about 250 acre-feet per annum produced in the reach between Lock and Dam No. 12 and Tennessee Colony Dam, or, a total of 1,100 acre-feet per annum would have to be dredged in order to maintain the minimum required channel depth and alignment. In the case of the channels in the reaches above the Livingston and Wallisvi, le Reservoirs, most of the sediment would be brought into the channels and transported into the respective reservoirs.

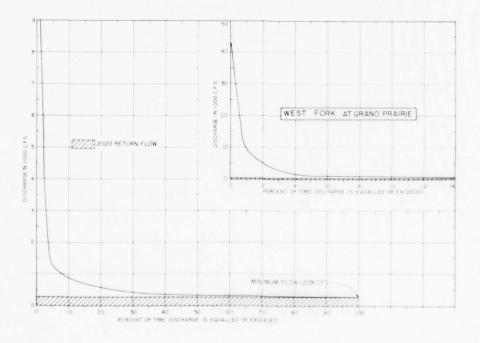
146. EFFECTS ON DESIGN WATER SURFACE. Sediment deposited in the multiple-purpose channel that would have to be dredged or removed would be spoiled along the old river channels and banks in the vicinity of the channel. The effects of sediment deposition in the restricted overbank areas of the leveed floodways were estimated to result in an increase in the design water surface of about 0.5 foot. The corresponding increase in the wider, unleveed floodplain would be even less. The maximum increase in the hydraulic flow line would not be effective until after 100 years of operation of the entire system. In view of the ample

freeboard provided by the proposed levees it is felt that no allowance was necessary in the levee grade or design water surface for this encroachment.

147. FLOW-DURATION STUDIES. - Water resource data for 2020 conditions of basin development were used to determine the runoff at selected stream-gaging stations for the period January 1924 through June 1957. Daily routing studies were made assuming the full system of existing and proposed reservoirs were in operation. Municipal, industrial, and irrigation water requirements for the year 2020 as determined by the Department of Health, Education and Welfare were supplied from existing and proposed reservoirs. The flow-duration curves are shown on plates 70 and 71.

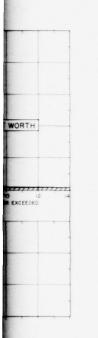






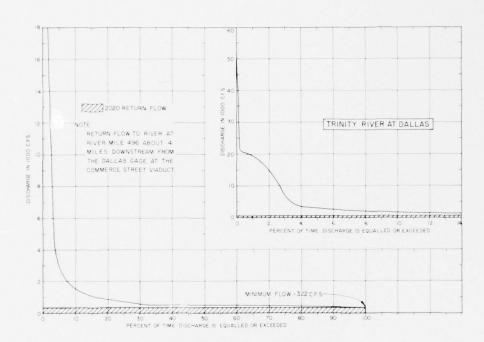
2 Curves are ba shed improved diversions, rel minor reserve etc., that are a 2020

3 The reservoirs 2020 condition and shown of 4 The 2020 returnished by the and Welfare.



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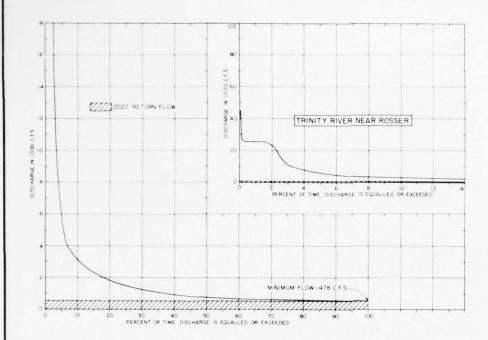


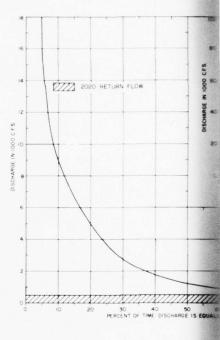
- NOTES: I Period of record January 1924 through June 1957
 - 2 Curves are based upon flows resulting from watershed improvements, including major reservoirs, diversions, return flows, land treatment, pands and minor reservoirs, flood-water retarding structures, etc. Incl. are assumed to be effective in the year.
 - 3.The reservoirs that are assumed operative under 2020 conditions are listed on tables 2, 4, 15 &16 and shown on plate 13.
 - 4 The 2020 return flows are based on estimates furnished by the Department of Health, Education

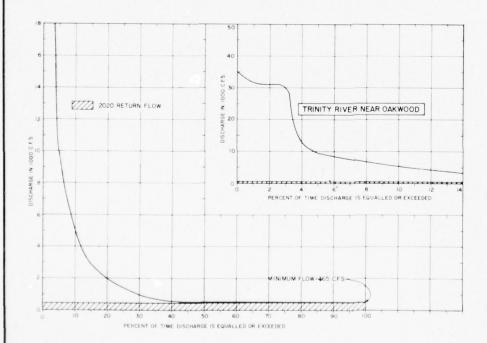
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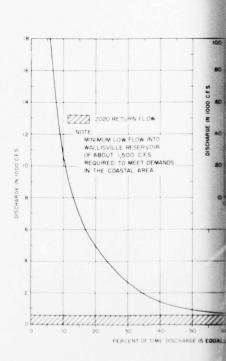
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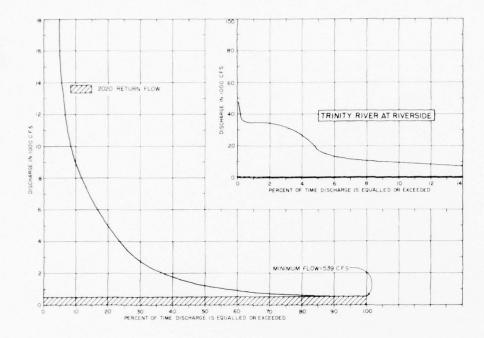
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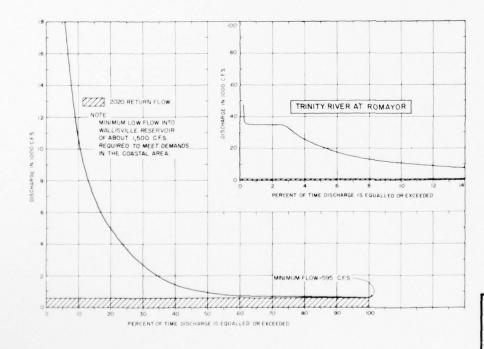








NOTE
See Notes on Sheet /



TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER

FLOW DURATION CURVES

US ARMY ENGINEER DISTRICT, FORT WORTH

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US ARMY ENGINEER DISTRICT, FORT WORTH

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148. NAVIGATION DESIGN FLOOD. The reference plane for measuring vertical bridge clearances in nontidal waters (as set forth in EM 1145-2-320 dated March 22, 1962) should normally be referred to the water stage or elevation which is not exceeded more than two percent of the time. The flow-duration curves of plates 70 and 71 were used to establish flows which would not be exceeded more than two percent of the time. Discharges for the navigation design flood used to establish the two percent flow line are shown in the following tabulation:

Gaging station	:	Discharge equalled or exceeded 2% of time (cfs)
Fort Worth		3,200
Grand Prairie		5,000
Dallas		14,000
Rosser		23,000
Oakwood		31,000
Riverside		34,000
Romayor		35,000

149. DEPTH OF WATER AVAILABLE FOR NAVIGATION. - Table 68 shows the proposed normal elevations of the various navigation pools of the multiple-purpose channel and the depth of water in feet between the normal pool elevations and the design gradients of the multiple-purpose channel at the approach and discharge channels adjoining the movable navigation dams. These depths would be available during the occurrence of low and medium low flows. Depths of 15, 42, and 39.5 feet in Pools Nos. 1, 5B and 10B would prevail under conditions of full conservation storage in the Wallisville, Livingston, and Tennessee Colony Reservoirs, respectively. When conservation storage in these reservoirs would be fully depleted, a depth of 12 feet would be provided for navigation through these reservoirs. During passage of high flows, such as the two percent flood discharges (regulated), operating discharges, or the minimum channel discharges, the depths of water in the various pools would be increased due to backwater conditions in the channel. The extent of backwater depth in the various pools for the two percent flood discharges (regulated) is shown graphically on plates 66 through 69. These graphical presentations show that the depths of water available for navigation in the various pools are materially increased during periods of high flows in the channel.

PERTINENT DATA CONCERNING FLAN OF IMPROVEMENT FOR MILITELE-PURDOGE TRINITY RIVER CHANNEL TO FORT WORTH, TEXAS

Depth 	39.5	12.0	26.0	12.0	30.0	16.31	12.0	24.0	12.0	13.0	12.0	12.0	12.0	12.0	12.0	25.0	12.0	12.0	12.0	21.33	11.18	5.0	5.9		
(MSL)	362.5	270	284	25.50	308	90 9	308	% %	2013	1	8 98	372	21.0	× %	356	124	424	XX	83	084	680	180	180		
Fool Fo.	108	ä :	115		13		13	77	14	27	19		1		18	61	19	20	88	7					
Minimum		35,000	000.20	000'28	2	2,000	32,000	32,000	27,000	27,000	27,000	27,000	27,000	25,000	72,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000
Operating : Minimum discharge : design		28,000	25.000				25,000	25,000	20,000	20,000	20,000		20,000		12,000		12,000		12,000	12,000	12,000	72,000	12,000		12,000
Grade (\$)		None	9680	None	S CALOTTE	0.04078	None	0.04044	None	0.03451	0.03753	0.03701	None	0.06482	None	0.05427	None	0,05109	None	0.05524	0.05524	0.1000	0.1050	0.1050	15000
		150	200				150	150 0.	081	150 0.	150 0.		120	150 0.	150	200 0.	200		500	150 0.	150 0.	150 0	150 0.		200
(feet)	(18)																								
: Elevation :	223.0(18)		0.88	272.0	272.0	291.69	28.0	306.0	314.0	33.00	35.0	360.0	360.0	384.0	384.0	0.20	412.0	426.0	0.044	458.67	MAR RO	475.0	477.3	480.25	
Length (miles)		15.60(19)	98.80	3.24	4 36	2.00	3.38	5.62	2.31	\$.7	98.9	-	5.31	5.99	5.21	3.49	5.91	5.19	3.07	2.63	3.48	1.17	0.38	0.57	1.28
Channel: mile(1)	5	4	274.51	283.40	286.64	293.00	295.00	8.8	36.32	311.25	317.81	100,000,900	331.31	00 400	100 S		346.00	200	351.10		362.80(21)	366.28	4:18	367.83	368.40
Lock & dam	-	1	12		13		,	*	15	16	17		18		10	•	8	2	51						
Lock & dem	1			20.31	1	29.0	1	1	1	1	,	12.00	1	12.0		1	1	16.0	-		20.00	12.0	12.0	12.0	200
: (feet)(2) & dam	0.0 13.36	0 13.36	15.0	27.0	17.6		1	36 32.5	36 12.0	36 12.0	,		101 12.0 18		0.04	42.2	138 12.0	1	0.92	O. aa		210 12.0	210 12.0		
: Elevation : Depth Lock : (MSL) : (feet)(2) & dam	0.0 13.36	0 13.36	15.0	27.0	17.0		17	32.5	12.0	34.0	13.01		12.0	101	0.54	138 42.2	12.0	16.0	26.0	210 44.0				235	2 090
Pool : Elevation : Depth Lock : No. : (MSL) : (feet)(2) & dam	Tridal 0.0 13.36	Tride. 9 13.36	1 4 15.0	و و.	4 17.6	2 16	10 10	3 36 32.5	36 12.0	3 36 12.0	60 13.01	8	54 101 12.0	101	131 150	138 42.2	7 168 42.0	7 168 16.0 8 192 40.0	9 198 26.0	9 210 44.0	010	210	104 236	104 235	2 040
Pool : Elevation : Depth Lock : No. : (MSL) : (feet)(2) & dam	Trian 0.0 13.36	None Tridel 0 13-36	1 4 15.0	7 000'54	45,000	45,000 2 16	45,000	2 16 12.5 45.000 3 36 32.5	36 12.0	12.0 12.0 14.0	60 13.01	09	5.4 101 12.0	None 5.A 101	45,000(9) 28 131 42.0	45,000 6 138 42.2	45 000 7 158 12.0	7 168 16.0 8 192 40.0	45,000 8 198 26.0	45,000 9 210 44.0	15,000(16)	210	2 210	None 10A 235	2 090
: Operating: Minimum: Pool : Elevation: Depth Lock discharge: design: No. : (MSL) : [feet](2) & dam	Trian 0.0 13.36	Tride. 9 13.36	15.0	و و.	35,000 45,000	2 16	10 10	2 16 12.5 45.000 3 36 32.5	36 12.0	12.0 12.0 14.0	60 13.01	8	5.4 101 12.0	101	131 150	138 42.2	35.000 ks.000	7 168 16.0	35,000 45,000 8 3.90 26.0	35,000 45,000 9 210 44.0	35,000(16) 45,000(16)	210	2 210	104 235	360.5
irade : Operating : Minimum : Pool : Micration : Depth Lock (\$) : discharge : design : No. : (NNL) : (feet)(2) & dam	Tridal 0.0 13.36	None Tridel 0 13-36	1 4 15.0	7 000'54	45,000	45,000 2 16	45,000	2 16 12.5 3 36 32.5 3 36 32.5	36 mm lis mm	25 mm 15 mm 4 60 34.0	60 13.01	09	5.4 101 12.0	None 5.A 101	45,000(9) 28 131 42.0	45,000 6 138 42.2	45 000 7 158 12.0	7 168 16.0	45,000 8 198 26.0	45,000 9 210 44.0	15,000(16)	210	9 210	None 10A 235	2 090
Grade : Operating : Minimum : Pool : Elevation : Depth Lock : (\$) : discharge : design : No. : (NEL) : (feet)(2) & dam	Tridal 0.0 13.36	None None Tridal 0 13.36	150 None 35,000(6) 45,000(6) 4 15.0	300 0.01,985 35,000 45,000	35,000 45,000	35,000 45,000	35.000 45.000	2 16 12.5 6 norths 35,000 kg,000 3 36 20.5	26 12.0	3 36 12.0	35,000(3) 45,000(9) 60 9.27	99	Action 100 to 12.0	None None 54 101	35,000(9) 45,000(9) 58 131 42.0	35,000 45,000	35.000 ks.000	7 168 16.0	35,000 45,000 8 3.90 26.0	35,000 45,000 9 210 44.0	35,000(16) 45,000(16)	210	Active Active 9 210	None None 104 235	360.5
Grade : Operating : Minimum : Pool : Elevation : Depth Lock : (\$) : discharge : design : No. : (NEL) : (feet)(2) & dam	Tridal 0.0 13.36	150 Note None None Tridal 0 13.36	150 None 35,000(6) 45,000(6) 4 15.0	300 0.01,985 35,000 45,000	250 0.01565 35,000 45,000	250 0.02687 35,000 45,000	0.02687 35,000 45,000	2 16 12.5 6 norths 35,000 kg,000 3 36 20.5	26 12.0	3 36 12.0	0.0136 35,000(9) 45,000(9) 60 9.27	09	Mother Mother to 60 12:0	150 None None SA 101	150 None 35,000(9) 45,000(9) 5B 131 42.0	150 0.01589 35,000 45,000	6 138 12.0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	7 168 16.0	150 0.02550 35,000 45,000 8 150 26.0	150 0.02643 35,000 45,000 9 210 44.0	150 0.02643 35,000(15) 45,000(16)	220 220	Active Active 9 210	150 None None None	108 269.5
ength : Elevation Withh Grade Operating Minimum : Pool : Elevation : Depth Lock miles) : (MEL) : (feet) : (\$) : disharge : design : No. : (MEL) : (feet)(2) & dam	-13.96(3) Trian 0.0 13.36	150 None None Fone 114dal 0 13.36	150 None 35,000(6) 45,000(6) 4 15.0	300 0.01,985 35,000 45,000	250 0.01585 35,000 45,000 1 4 17.6	250 0.02687 35,000 45,000	200 0.02687 35,000 45,000	3.5 20.5 12.5 3.5 200 A reside 35.000 k5.000 3 36 32.5	24.0 20 20 20 22.0 22.0 24.0 20 20 20 20 20 20 20 20 20 20 20 20 20	24.0 24.0 3.0 12.0 25.0 3.0 12.0 3.0 12.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3	16.29 150 0.0150 35,000(3) 45,000(3) 66 4.27	09	148.0 1.50 Mother mother the 60 12.0 18.0 18.0	150 None None SA 101	150 None 35,000(9) 45,000(9) 5B 131 42.0	150 0.01589 35,000 45,000	138 12.0 140 0 000082 35,000 ks 000	18.0	150 0.02550 35,000 45,000 8 150 26.0	166.0 150 0.02643 35,000 45,000 9 210 44.0	1.50 0.02643 35,000(16) 45,000(16)	220	198.0 170 motor motor 9 210 235 235 235 235	150 None None None	108 269.5
Elevention Width Grade Operating Windama Pool Elevation Depth Lock	-13.96(3) Trian 0.0 13.36	28.3 150 None None Tridal 0 13.36	7.20 150 None 35,000(6) 45,000(6) 4 15.0	8.00 45,000 45,000 45,000 45,000 45,000	3.95 -13 250 0.01595 35,000 45,000 1 4 17.6	-13.0 250 0.02687 35,000 45,000 5	- 1.3 - 1.3 - 200 0.02687 35.000 45,000	3.5 3.6 12.5 3.5 500 A ANNERS 35 000 14.000 3 36 32.5	24.0 20 20 20 22.0 22.0 24.0 20 20 20 20 20 20 20 20 20 20 20 20 20	24.0 24.0 3.0 12.0 25.0 3.0 12.0 3.0 12.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3	10) 46.99 150 0.0136 35,000(g) 45,000(g) 66 9.27	0.64	1,00(11) 48.0 120 Note Note 12.0	89.0 150 None None None 5A 101	48.72 8e.n(13) 150 None 35,000(9) 45,000(9) 58 131 42.0	95.8 150 0.01589 35,000 45,000 6 138 42.2	126.0 126.0 126.0 127.0 127.0 127.0 127.0	18.0	150 0.02550 35,000 45,000 8 150 26.0	11.75 150 0.0643 35,000 45,000 9 210 44.0	14) 4.9(15) 150 0.08643 35,000(16) 45,000(16)	196.0	198.0 170 motor motor 9 210 235 235 235 235	0.61(17) 223.0 150 None None None 10A 235	33.61 108 262.5 35.5

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Detence is miles from Sharron Ship Channel.

The Ship of Channel below alentin of sermal policy and low used low tide datum which is 1.96 feet below mens see least of the ship of the shi

Junction of flood release channel to Tennessee Colony Reservoir spillway and navigation channel to lock No. 104.
Flood release channel Text Text Text Text Colony Reservoir spillway to channel size 29; 70.
Distabling from gated spillway of Textnessee Colony Reservoir Vien Conservation pool 1st full to elevation 26.5.
Dannel Cort artifaction only in land cut below Textnessee Colony Reservoir Vien Conservation pool 1st full to elevation 25.6.
Channel Cort artifaction only in land cut below Textnessee Colony Reservoir provides 12-foot mayight depth when conservation stokes of Channel service is fully depth-service against provides 12-foot mayight depth throughout pool 1st formersee Colony Reservoir provides 12-foot mayight depth below none. Foot shorten 1st foot control attention 25.6.
Thannel within Thod-control atomagn pool of Textnessee Colony Reservoir provides 12-foot mayight depth below none. Foot shorten 1st foot control at 25 and 25 and

(21) (22)

150. DISCHARGES CONSIDERED. - Flow-duration curves for the multiple-purpose channel under 2020 conditions of watershed development (including the effects of all reservoirs presented in the plan of improvement) are shown on plates 70 and 71. Inspection of these curves reveals that the discharges occurring two percent of time are of lesser magnitude than either the operating discharges or the minimum channel capacities at the various stream-gaging stations, as shown in the following tabulation:

Gaging station	<pre>: 2 percent floo :discharge regula : (cfs)</pre>			
Fort Worth	3,200	12,000	15,000	
Grand Prairie	5,000	12,000	15,000	
Dallas	14,000	20,000	25,000	
Rosser	23,000	25,000	32,000	
Oakwood	31,000	35,000	45,000	
Riverside	34,000	35,000	45,000	
Romayor	35,000	35,000	45,000	

151. Operating discharges would occur more frequently and for greater periods of time than discharges at the recommended minimum channel capacities. Since the operating discharges are approximately the same as the minimum channel capacities to be provided, further discussion of the effect of large flows on navigation will be limited to the operating discharges for the multiple-purpose channel.

152. DURATION OF FLOWS AT OR ABOVE OPERATING DISCHARGES.—
Table 69 shows the percent of time regulated flows in the multiplepurpose channel would equal or exceed operating discharges at each
lock on the channel, based on the flow-duration curve data shown on
plates 70 and 71, for the various stream-gaging stations. The data
in table 69 show that flows equalling or exceeding operating discharges
at the locks upstream from the Livingston Dam would occur less than
one percent of time and that similar flows below the Livingston Dam
would occur about 2.7 percent of time. In this reach of channel, the
operating discharge of 35,000 second-feet would have a mean channel
velocity of about 3.3 miles per hour. The data in table 69 reveal
that the occurrence of high flows on the channel would not be of long
duration and apparently would not be seriously detrimental to navigation
excepting below the Livingston Dam where speed of towboats would be
affected by the velocities at high flows.

TABLE 69

PERCENT OF TIME OPERATING DISCHARGE IS EQUALLED OR EXCEEDED AT PROPOSED TRINITY RIVER LOCKS & DAMS

(BASED ON FLOW DURATION CURVES FOR 2020 CONDITIONS AT DESIGNATED STREAM-GAGING STATIONS)

Gaging station or lock number	:	ation	at gaging	operating: is equal	lled or
			: station : (cfs)	at gage;	
Fort Worth Gage Lock & Dam No. 21 Lock & Dam No. 20	558.3	374.9 360.17 351.91		.6	·7 ·8
Grand Prairie Gage Lock & Dam No. 19	515.1	345·3 342·51	12,000		.8
Dallas Gage Lock & Dam No. 18 Lock & Dam No. 17 Lock & Dam No. 16 Lock & Dam No. 15 Lock & Dam No. 14	500.3	333.9 331.31 317.81 311.25 306.31 298.38	20,000		.4 .4 .4 .4
Rosser Gage Lock & Dam No. 13 Lock & Dam No. 12 Lock & Dam No. 11 Lock No. 10B & Tennessee Colony Lock No. 10A	451.4 Dam	298.0 286.64 274.51 258.91 233.61 233.00		.2	.2 .2 .2 (1)
Oakwood Gage Lock & Dam No. 9 Lock & Dam No. 8 Lock & Dam No. 7 Lock & Dam No. 6	313.4		35,000		.1 .1 .3
Riverside Gage Lock No. 5B & Livingston Dam Lock & Dam No. 5A	182.5	136.1 99.20 98.00)	•5	(3) (4)
Romayor Gage Lock & Dam No. 4 Lock & Dam No. 3	94.3		35,000	2.7	2.7
Liberty Gage Lock & Dam No. 2 Lock No. 1 & Wallisville Dam	40.3	47.8 47.45 28.30	35,000	(5)	2.7 2.7 2.7

(1) Lock No. 10B would be located in the west end of the Tennessee Colony Dam and in general there would be no flow in pool 10B.

(2) Lock No. 10A would be located in cut-off channel and no flow would occur in pool 10A.

(3) Lock No. 5B would be located in the west end of the Livingston Dam and in general there would be no flow in pool 5B, except in the upper end of the reservoir near the Riverside Gage.

(4) Lock No. 5A would be located in cut-off channel & no flow would occur

in pool 5A.

(5) Not determined, considered same as for Romayor Gage.

153. Further information concerning the number of days that regulated discharges would equal or exceed operating discharges during a recurrence of the three major floods of record at the various stream-gaging stations under 2020 conditions of watershed development is graphically shown on the hydrographs for the floods of April-July 1942, February-May 1945, and April-July 1957 presented on plates 23 through 37. A summary of the total number of days the modified flows would be equal or exceeded the operating discharges at gaging stations, as determined from the hydrographs of the three major floods is given in the following tabulation:

			mber of days modified exceed operating				
Gaging station	:Operating:equal or exceed operating discharges during :discharge. flood of:						
	: (cfs) :	Apr-Jul	1942 : Feb-May 19	45 : Apr-Jul 1957			
Grand Prairie	12,000	3	1	1			
Dallas	20,000	8	3	1			
Rosser	25,000	17	7	1			
Oakwood	35,000	4	2	0			
Riverside	35,000	5	17	3			
Romayor	35,000	67	49	0			

154. DURATION OF FLOWS AT OR ABOVE RECOMMENDED CHANNEL CAPACITY. - Analyses of the three major flood hydrographs reveal that the modified flows exceeded the recommended minimum channel capacities at and upstream from the Rosser gaging station, as shown in the following tabulation:

Gaging station	:Minimum :channel :capacity		mber of days mo exceed minimum during flood	channel capac	
	: (cfs)	: Apr-Jul	1942 : Feb-May		Mul 1957
Grand Prairie	15,000	0	1		1
Dallas	25,000	14	1		1
Rosser	32,000	6	2		0
Oakwood	45,000	0	0		0
Riverside	45,000	0	0		0
Romayor	45,000	0	0		0

155. In connection with the data presented in the above tabulation, it is noted that the proposed multiple-purpose channel would be located within the existing and recommended leveed floodways. The flows exceeding minimum channel capacities in this reach would be confined within the leveed floodways and would probably cause cessation of navigation because of adverse overbank currents, during periods when modified flows exceed minimum channel capacities. It is believed that the modified flows in the channel downstream from the floodways would not cause cessation of

navigation, based on the assumption that towboats of sufficient horse-power would be provided to move the standard barge tows of three 35-X 195-foot barges in tandem against the velocities that would accompany discharges at the minimum channel capacities.

156. VELOCITIES IN NAVIGATION POOLS. The estimated mean channel velocities resulting from operating discharges in each of the navigation pools and the percent of time the operating discharges would be equalled or exceeded are given in table 70. The data in table 70 show that a maximum mean channel velocity of 4.6 miles per hour would exist in the upper portion of Pool No. 11 approximately 0.2 percent of time. The average mean velocity in the pools would be more than 3.6 miles per hour for a very small percent of time upstream of the Livingston Dam, and about 2.7 percent of time in the pools below the Livingston Dam. The foregoing concerns the operating discharge velocities which would probably be experienced during recurrence of major floods on the multiple-purpose channel under 2020 conditions on the Trinity River Basin.

157. The percent of time that velocities of modified flows of lesser magnitude than the recommended operating discharges, are estimated to occur in the multiple-purpose channel at the various stream-gaging stations under 2020 conditions in the basin, is shown in the following tabulation. The data shown in the tabulation are based on the flow-duration curves and velocity curves for the several gaging stations.

Stream-gaging statio				in miles per hr :Two miles or
	: mile) :	less (% time):miles(% time	e):more (% time
Grand Prairie	345.3	98.0	1.1	0.9
Dallas	333.9	97.0	1.0	2.0
Rosser	298.0	91.5	5.0	4.5
Oakwood	220.6	96.0	0.7	3.3
Riverside	136.1	79.0	16.2	4.8
Romayor	75.8	89.5	5.5	5.0

TABLE 70 PERTINENT DATA CONCERNING MEAN VELOCITIES IN NAVIGATION POOLS DURING PASSAGE OF OPERATING DISCHARGE

	:			lean channe		:Percent of time
:Length :Operating:			velocities		:operating dis-	
Pool	of pool:d			(MPH)		charge is equalle
number	:(miles):	(cfs)	:Upper(1)	:Lower(2):	Average	: or exceeded
21	2.63(3)	12,000	2.2	1.3	1.75	0.7
20	8.26	12,000	2.5	1.2	1.85	0.8
19	9.40	12,000	2.5	1.5	2.0	0.8
18	11.20	20,000	4.1	1.9	2.75	0.4
17	13.50	20,000	3.6	2.2	2.9	0.4
16	6.56	20,000	3.6	2.5	3.05	0.4
15	4.94	20,000	3.7	3.1	3.4	0.4
14	7.93	20,000	4.2	3.0	3.6	0.2
13	11.74	25,000	4.3	2.3	3.3	0.2
12	12.13	25,000	3.5	2.6	3.05	0.2
11	15.60	28,000	4.6	0.4	1.35	0.2
10B	25.30	28,000	0.6	0.1	0.35	(4)
10A	0.61	(5)				
9	15.05	35,000	3.6	2.3	2.95	0.1
9	10.40	35,000	3.4	2.5	2.95	0.1
7	23.63	35,000	3.6	2.4	3.0	0.3
6	36.00	35,000	3.4	2.4	2.9	0.5
5B	48.72	35,000	2.1	0.1	1.1	(6)
5A	1.20	(7)				
4	23.15	35,000	3.6	3.1	. 3.35	2.7
3	15.77	35,000	3.9	2.7	3.3	2.7
3 2	11.58	35,000	4.0	2.5	3.25	2.7
1	19.20	35,000	3.2	2.5	2.85	2.7

- (1) Velocity at upper end of pool.
- (2) Velocity at lower end of pool.
- (3) From junction with flood-control channel to Lock 21.(4) Negligible, based on full conservation pool at Tennessee Colony Reservoir.
- (5) Lock 10A would be located in cut-off and no flow would occur in pool 10A.
- (6) Negligible, based on full conservation pool at Livingston Reservoir.
- (7) Lock 5A would be located in cut-off and no flow would occur in pool 5A.

- 158. EFFECT OF VELOCITIES ON NAVIGATION. The data presented in the foregoing tabulation indicate that the durations of velocities of one mile per hour or less produced by regulated discharges in the multiple-purpose channel would be as follows: more than 90 percent of time upstream of the Oakwood Gage, 79 percent of time at the Riverside Gage, and about 90 percent of time at the Romayor Gage. These data also indicate that the navigation pools generally would be at normal elevation, or slack water condition, and that the velocity of channel flow in the various pools would not materially affect navigation after full development of the Trinity River Basin reservoir system.
- 159. DISCHARGE FREQUENCY. Observed records are available at various gages on the Trinity River and tributaries. Based upon these observed records, flows under 1958 (existing) conditions of watershed development were estimated for the areas above the existing reservoirs and for the incremental areas between the existing reservoirs and downstream gages for the period 1924 through 1959. Flows for the same period were also estimated under 2020 conditions of watershed development for the areas above all reservoirs considered in the plan of development and for the incremental areas between these reservoirs and downstream gages. Period of record routings were made through the system of existing reservoirs to downstream gages under 1958 conditions of watershed development and through the system of reservoirs considered in the plan of improvement to downstream gages under 2020 conditions of watershed development. The peak discharges produced at downstream gages under existing (1958) conditions and under the plan of development (2020 conditions) were then used to construct discharge-frequency curves at selected downstream gages in accordance with the graphical methods set forth in Leo R. Beard's "Statistical Methods in Hydrology" (distributed with Civil Works Engineer Bulletin 52-24, dated August 26, 1952). The discharge frequency curves thus constructed for existing (1958) conditions and conditions that would obtain under the plan of development (2020) have been used as a basis for the economic studies presented in Appendix IV, Flood-Control Economics. An example of these curves for reach 3 (Midway Gage) is shown on figure 1 of Appendix IV.

HYDRAULIC DESIGN

- 160. GENERAL. Studies were made to determine the hydraulic characteristics under existing conditions and various plans of improvement on the Trinity River and its tributaries, particularly within the limits of the multiple-purpose channel between Fort Worth, Texas, and the mouth of the river. The following paragraphs describe the hydraulic studies made on the Trinity River, West Fork, Elm Fork, East Fork, Mountain Creek, Duck Creek, and their major tributaries.
- 161. WATER SURFACE PROFILES EXISTING CONDITIONS. Hydraulic computations were made to establish water surface profiles and limits of flooding under existing conditions on the Trinity Alver and its major tributaries between Fort Worth and the mouth of the river. Backwater studies were based on Manning's formula, in accordance with paragraph 10 of EM 1110-2-1409, December 7, 1959, using roughness coefficients of 0.035 to 0.060 for the existing channels and 0.060 to 0.120 for the overbanks. The backwater studies were further correlated with observed highwater data and measurements at U. S. Geological Survey gages on the Trinity River and its tributaries. Plates 2 through 12 show the profiles of the Trinity River and its tributaries under existing conditions and the profiles for the flood of record under historical conditions.
- 162. CHANNEL CAPACITIES. Existing channel capacities for reaches of the Trinity River and its tributaries were determined by backwater computations, correlated with observed discharge measurements. The existing channel capacities for the Trinity River and its principal tributaries, and the capacities of the improved channels are shown in table 64.

163. PLAN OF IMPROVEMENT. -

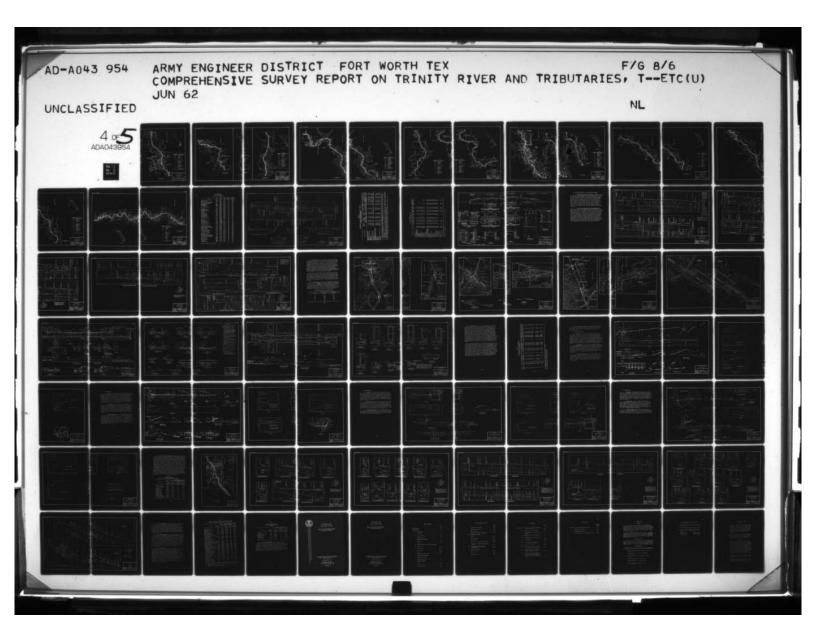
a. Channel. The design of the multiple-purpose channel is based on a consideration of the requirements for navigation, flood control, and reservoir regulation. Various size channels were investigated to satisfy these three requirements. Channel size formulation studies for navigation show that a channel having dimensions of 12 feet deep and 150 feet of bottom width, with side slopes of 1 vertical on 2 horizontal, would be the most economical for modern barge navigation required to transport the prospective commerce on the channel. Channel-size studies for flood control and reservoir regulation indicated that the most feasible channel for these purposes would more nearly follow the existing river alignment, including certain river bend cut-offs, and clearing only in portions of the existing river channel. The recommended multiple-purpose channel incorporates the most advantageous and feasible features of the requirements for each of the purposes. This includes enlargement of the navigation channel by deepening and

widening where necessary to provide sufficient capacity for passage of operating discharges from the existing and recommended flood-control reservoirs on the watershed and to provide additional capacity for runoff from the uncontrolled drainage areas below the reservoirs. The general plan of the multiple-purpose channel project is shown on plates 72 through 79. Pertinent data concerning the design dimensions and capacities of the multiple-purpose channel from the Houston Ship Channel to the lower end of the Fort Worth Floodway are given in table 68. Generally, channel dimensions established in this report cover long reaches of the river. However, during preconstruction planning studies more detailed surveys will be available. Actual channel sizes will then be established based on local requirements and topography.

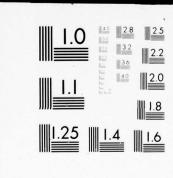
- b. Levees. The existing levees downstream from Five Mile Creek, with the exception of the recommended Liberty levee, are agricultural levees and would provide protection from floods in excess of 100-year frequency under improved channel conditions. The levees for the existing Fort Worth and Dallas Floodways, which would become a part of the improved floodway, have a minimum freeboard of 4 feet above the water surface elevation resulting from the standard project flood discharge. Levees generally along both banks of the improved channel from Five Mile Creek to the existing Dallas Floodway and from Elm Fork to the existing Fort Worth Floodway, would therefore be designed to provide a minimum freeboard of 4 feet above standard project flood discharge levels. All levees upstream from Five Mile Creek would be provided with a minimum top width of 10 feet and have 1 on 2.5 side slopes. Table 71 gives the pertinent hydraulic design data for the multiplepurpose channel and levees upstream of Five Mile Creek. The Liberty local protection project would consist essentially of levees along the left bank of the Trinity River. These levees in conjunction with the recommended multiple-purpose channel would provide protection from a standard project flood having a peak discharge of 180,000 second-feet. A minimum freeboard of 4 feet above the design water surface would also be provided for the Liberty levees. Levees hydraulically constructed would have a minimum crown width of 20 feet and side slopes varying from 1 on 20 to 1 on 3, depending upon the natural repose of the hydraulically placed material. The plan of improvement for Liberty is shown on plate 58 and the profile of the proposed levee is shown on plate 80.
- c. Bridge Improvements. The plan of improvement provides for all railroad bridges over the navigation channel to be of the vertical lift type. The lift bridges would provide a minimum vertical clearance of 50 feet in open position above the stage that governs 98 percent of the time and a minimum vertical clearance of 3 feet in closed position above elevation of maximum high water or standard project flood design water surface in leveed floodways, as may be applicable at the bridge site. Table 72 gives pertinent design data for railroad bridges on the multiple-purpose channel. The plan of improvement for all highway bridges over the navigation channel are based on providing a

minimum vertical clearance of 50 feet above maximum navigation elevation, which in all cases would exceed the minimum low steel level required for the passage of flood releases. Table 73 gives information concerning design data for highway bridges. Bridges above the limits of navigation on the Trinity River and on tributaries above Five Mile Creek would provide a minimum freeboard of three feet between low steel and the water surface level of the standard project flood. Typical highway and bridge details are shown on plate 81.

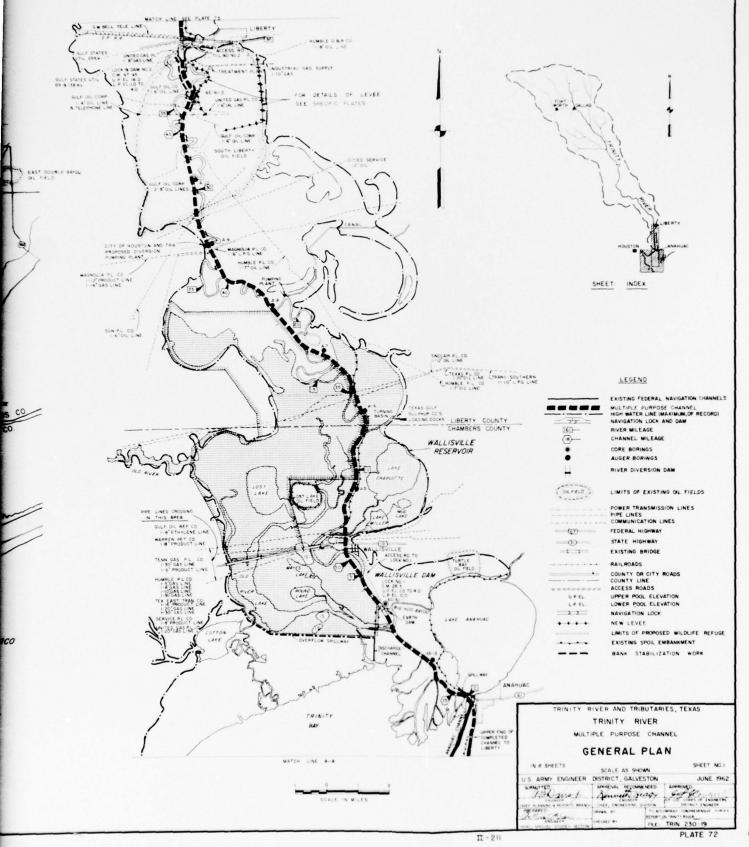
d. Interior Drainage. Details for interior drainage facilities in the existing, authorized, and previously recommended floodways are set forth in the appropriate design memorandums and plans for construction of the floodways. For all new levee systems, with the exception of the leveed area at Liberty, the interior drainage will be controlled by gravity sluices and sump storages to provide protection from flooding of the interior areas from storms having a frequency of recurrence of once in 100 years. In addition to gravity sluices, the leveed area at Liberty will be provided with a 40,000 gpm pump in the Big Bayou interior drainage area and a 150,000 gpm pump in the Clayton Bayou interior drainage area as shown on plates 58 and 80. The location of sumps and tabulation of the pertinent data for the gravity sluices and sumps are shown on plates 52 through 58.

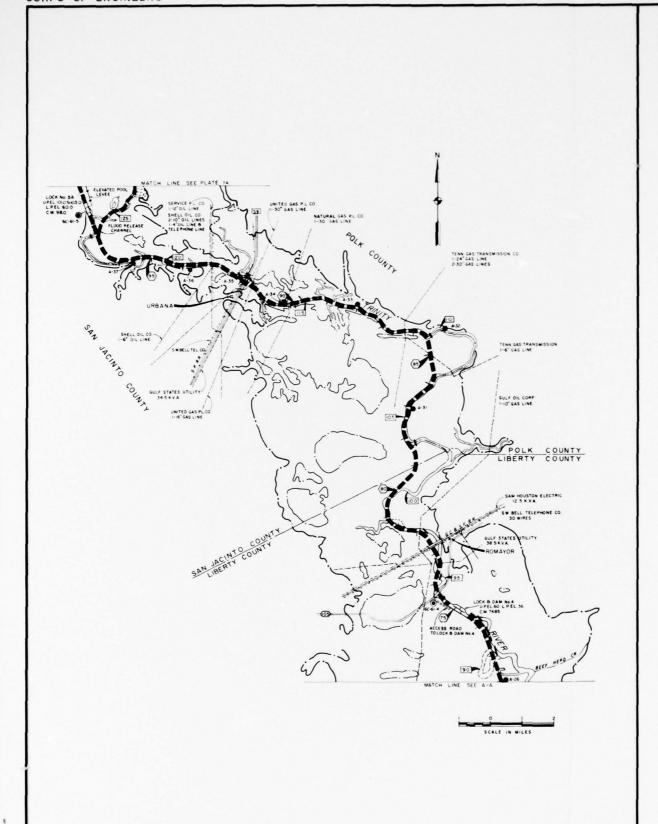


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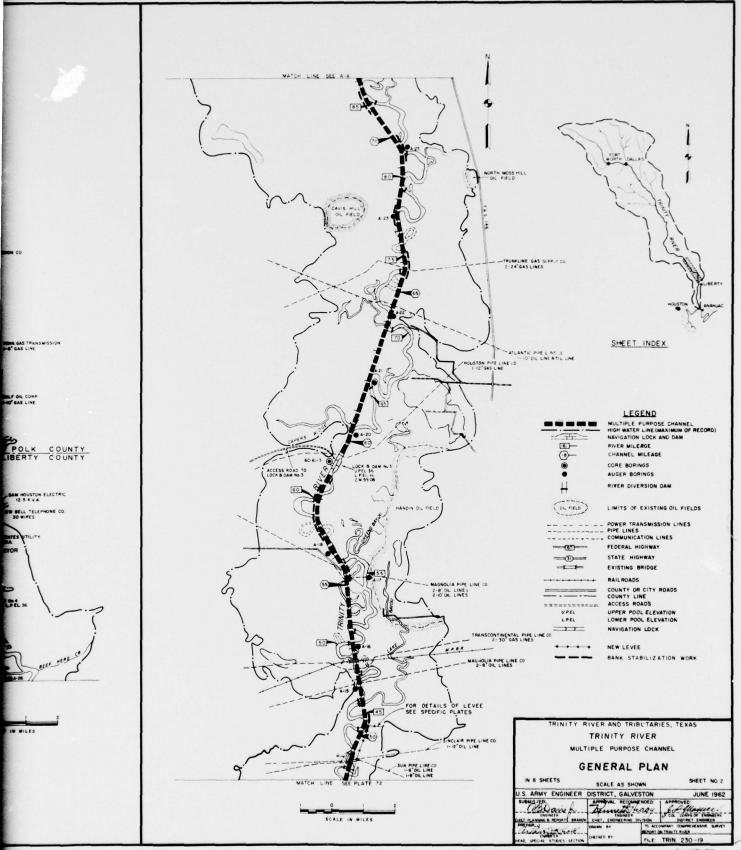


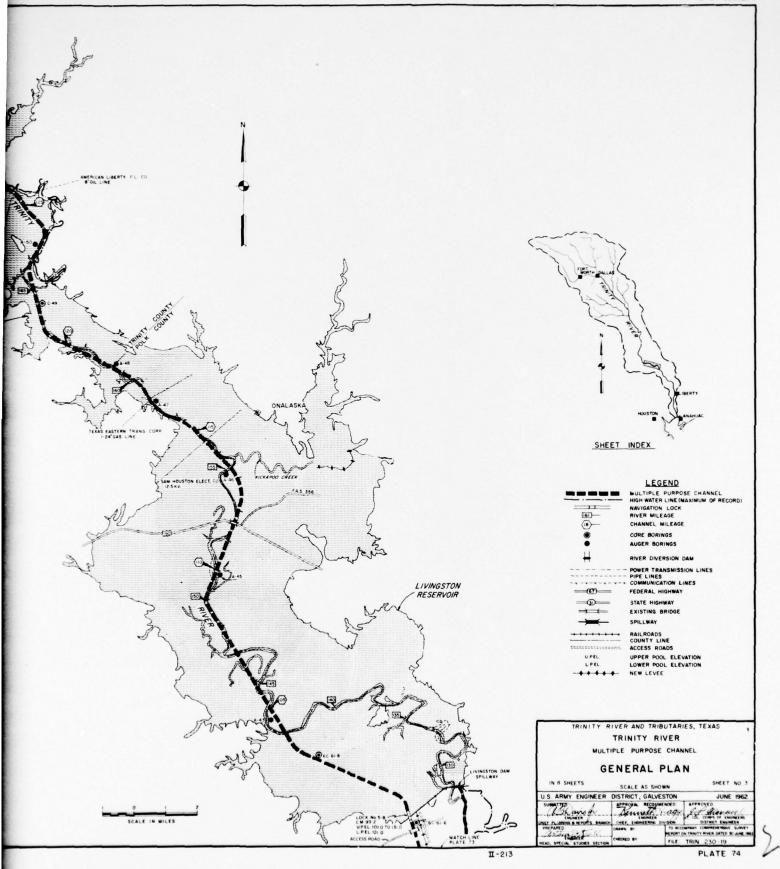
MICROCOPY RESOLUTION TEST CHART NATIONAL BUREAU OF STANDARDS 1963 A

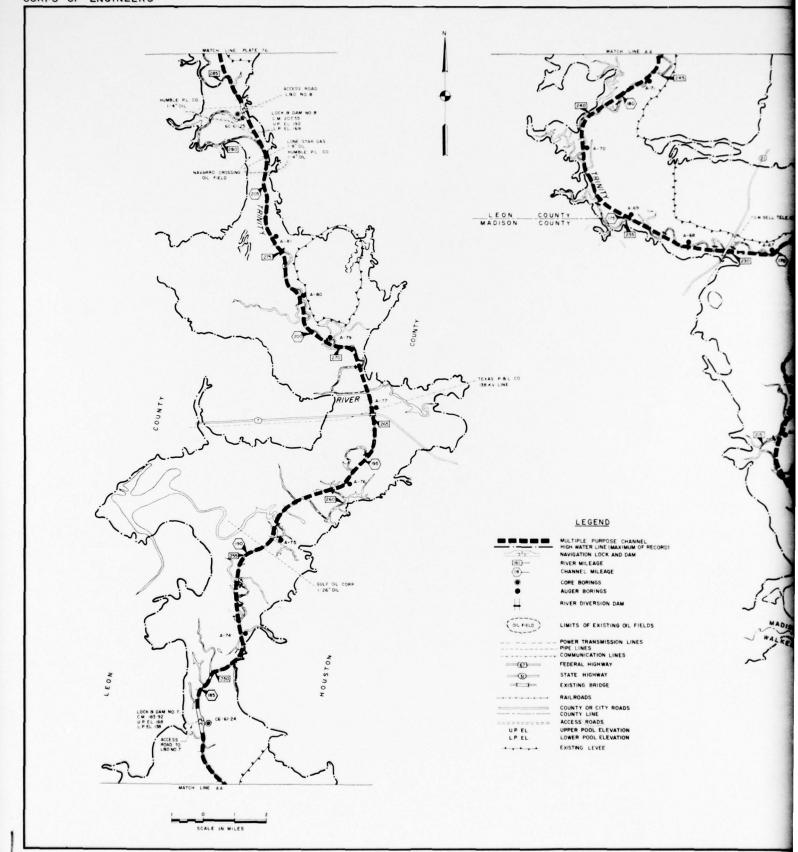


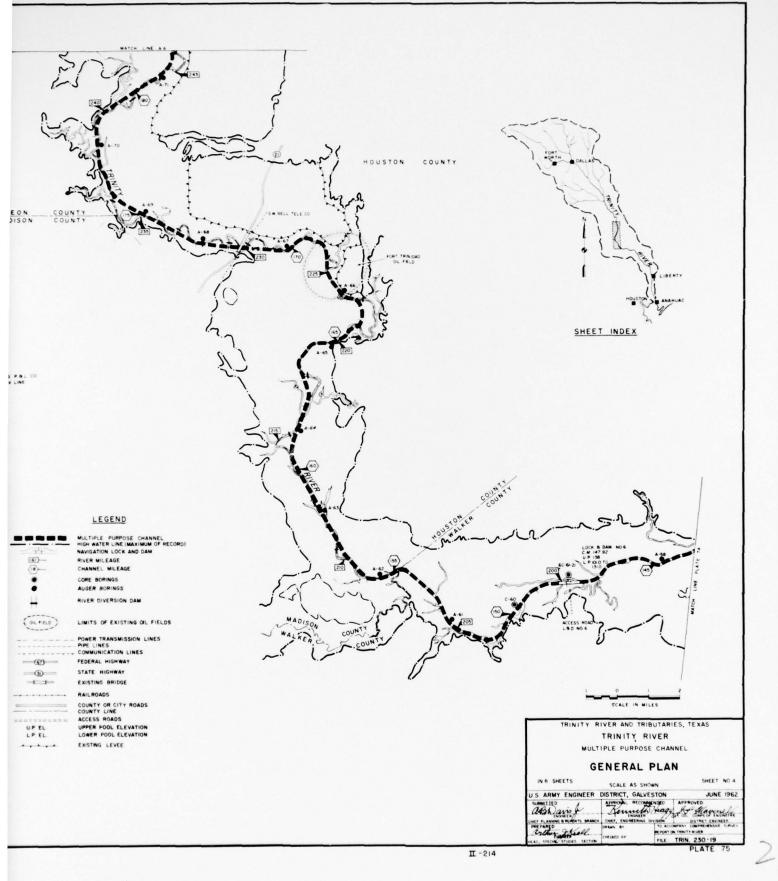


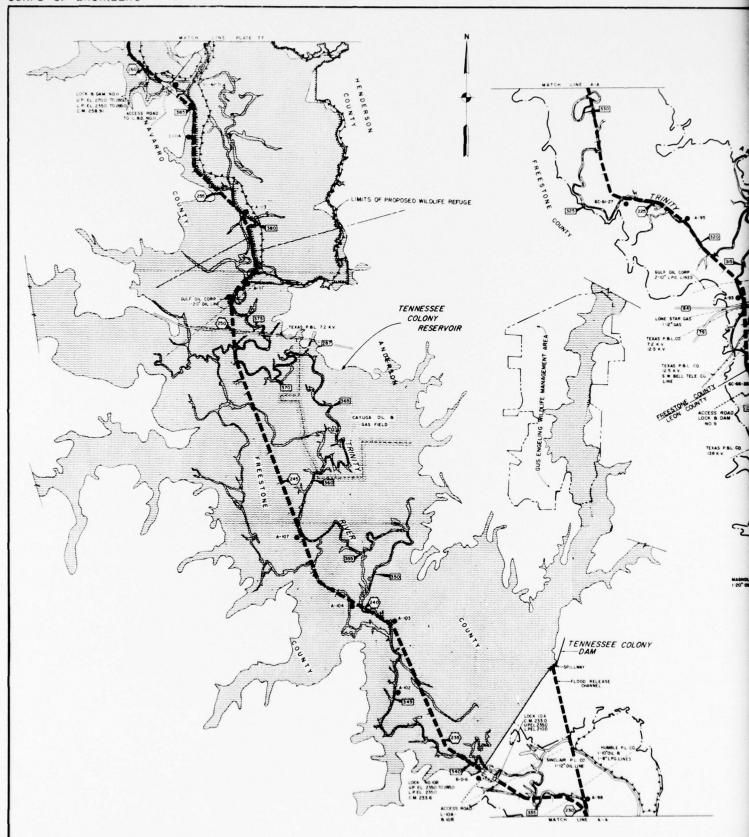


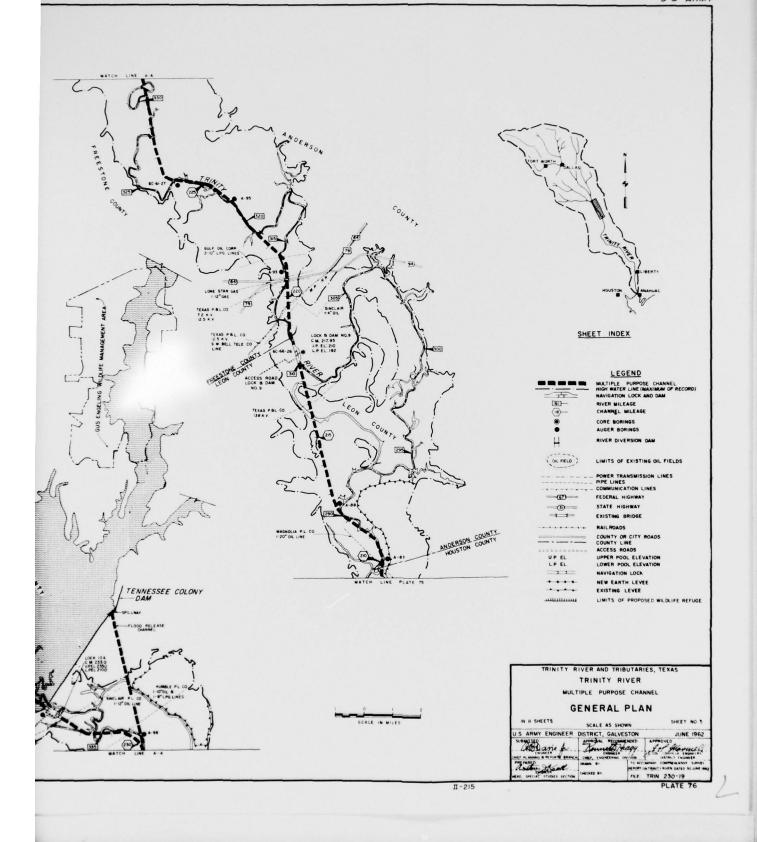


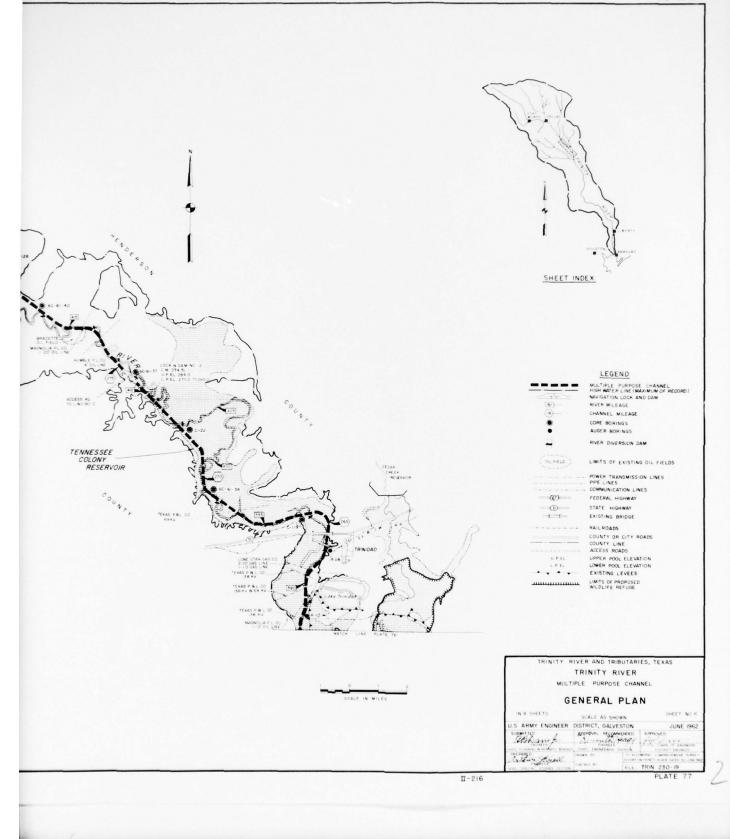










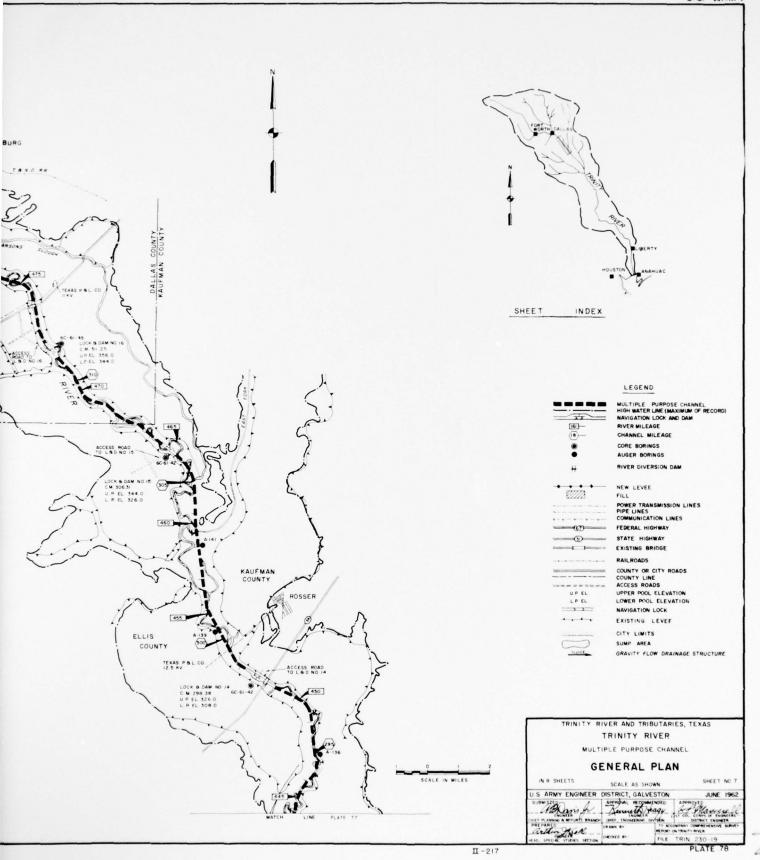


U.S. ARMY

BORING LEGEND

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ST 88



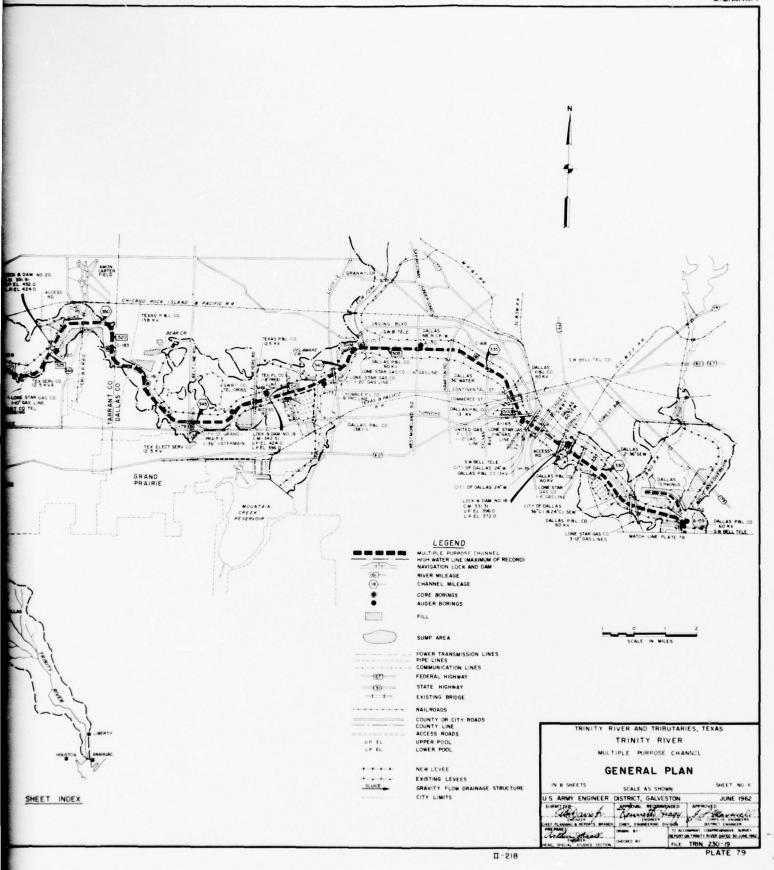


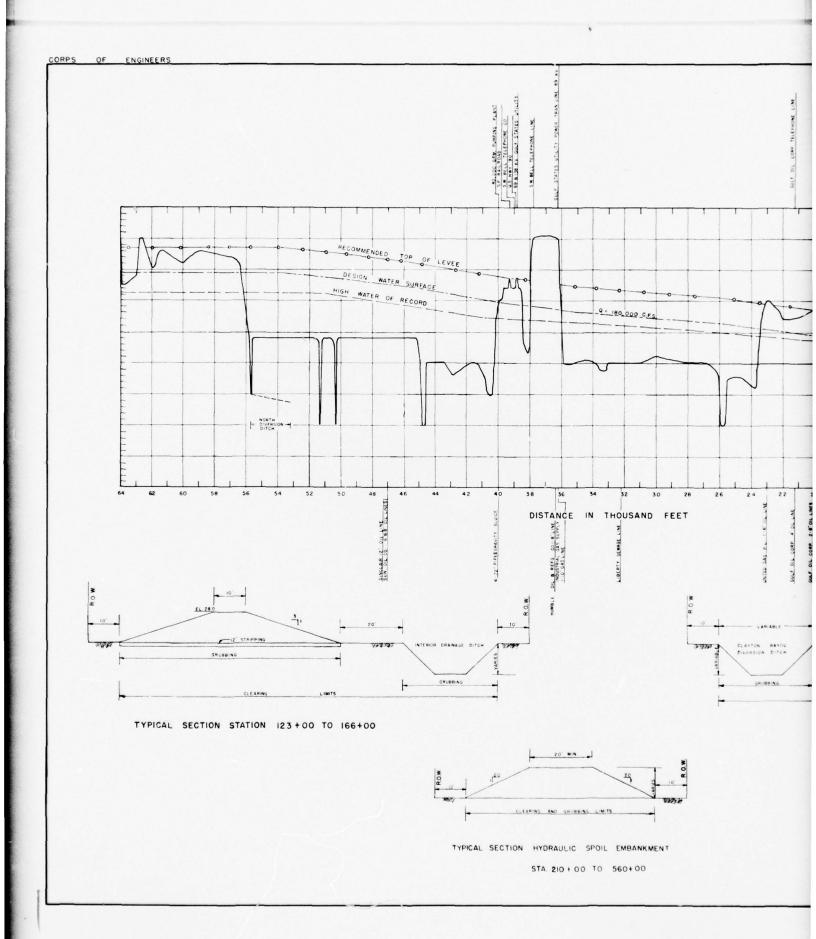
TABLE 71

HYDRAULIC DESIGN DATA MULTIPLE-PURPOSE CHANNEL

FIVE MILE CREEK TO FORT WORTH, TEXAS

Five Mile Creek Diversion Channel Grade Control Change Highway Loop 12 Honey Springs Branch Diversion Channel	321.50 326.00	3.71. 600			
Grade Control Change Highway Loop 12		174,600	351.22	150	396.2
Highway Loop 12	520.00	174,600	360.00	150	404.5
	326.02	174,600	360.00	150	404.6
	326.15	174,600	360.00	150	404.8
White Rock Creek Diversion Channel	326.62	174,600	360.00	150	405.7
Above Mouth White Rock Creek	JE0.02	163,800	360.00	150	40).1
%NO Railroad	328.30	163,800	360.00	150	408.4
	328.46	163,800	360.00		408.6
Interstate Highway 45 MKT Railroad			360.00	150	
Forrest Avenue	330.28	163,800	360.00	150	411.1
	330.65	163,800		150	411.6
G.C. & S.F. Railway	331.09	163,800	360.00	150	412.2
Lock & Dam No. 18 (D. S.)	331.31	163,800	360.00	150	412.3
(U. S.)		163,800	363.50	150	413.3
Corinth Street	331.41	163,800	363.84	150	413.5
Cadiz Street	332.22	163,800	366.61	150	414.8
Interstate Highway 35E	332.28	163,800	366.82	150	414.9
Houston Street	332.61	163,800	367.95	150	415.5
Dallas-Fort Worth Turnpike	333.12	163,800	369.69	150	416.3
Commerce Street	333.50	163,800	370.99	150	417.0
C&P Railway	333.66	163,800	371.54	150	417.2
Continental Street	333.93	163,800	372.47	150	417.7
Sylvan Avenue	334.89	163,800	375.75	150	419.2
Hampton-Inwood Road	336.33	163,800	380.68	150	421.4
Vestmoreland Avenue	337.26	163,800	383.86	150	422.9
Frade Control Change	337.30	163,800	384.00	150	422.9
Elm Fork Confluence	338.80	163,800	384.00	150	425.5
Above Mouth Elm Fork	-	160,000	384.00	150	425.5
State Highway Loop 12	340.39	160,000	384.00	150	430.0
Mountain Creek	340.89	160,000	384.00	150	431.3
Lock & Dam No. 19 (D. S.)	342.51	160,000	384.00	150	435.3
(U. S.)	-	160,000	402.00	200	436.3
Meyers Road	342.9	160,000	403.20	200	438.0
Mouth Bear Creek	-	160,000	-	200	-
Above Mouth Bear Creek		160,000(1)		200	_
Beltline Road	345.25	160,000(1)	409.85	200	446.1
Frade Control Change	346.00	160,000(1)	412.00	200	448.9
Bear Creek Diversion Channel	346.83	160,000(1)	412.00	200	451.5
C.R.I.&P R.R. Spur	350.54	148,000	412.00	200	459.1
State Highway No. 360	350.75	148,000	412.00	200	459.5
Lock & Dam No. 20 (D. S.)		148,000	412.00	200	461.2
	351.91				
(U. S.)	0.00	148,000	426.00	200	462.2
F. M. Highway No. 157	354.00	148,000	431.64	200	469.8
Innamed Creek Diversion Channel	355.13	148,000	434.69	200	473.0
Sulphur Branch Diversion Channel	356.08	148,000	437.25	200	475.6
Above Sulphur Branch Diversion Channel	-	138,000	-	200	475.6
Arlington Bedford Road	357.00	138,000	439.70	200	478.2
rade Control Change	357.10	138,000	440.00	200	478.5
Village Creek	358.10	138,000	440.00	200	480.8
Above Mouth Village Creek	140	117,700	440.00	200	480.8
Walker Branch Diversion Channel	359.79	117,700	440.00	200	483.5
Arlington-Smithfield Road	359.95	117,700	440.00	200	483.8
ock & Dem No. 21 (D. S.)	360.17	117,700	440.00	200	484.1
(U. S.)	300.11	117,700	451.00	150	485.1
Innamed Creek Diversion Channel	261 12		453.80		489.3
	361.13	117,700	456.56	150	
lighway Loop 820	362.11	117,700		150	493.7
Mandley-Ederville Road	362.70	117,700	458.38	150	496.3
Big Fossil Creek Diversion Channel	362.92	117,700	459.02	150	497.2
bove Big Fossil Creek Diversion Channel		95,000	10	150	497.2
ittle Fossil Creek Diversion Channel	363.68	95,000	461.24	150	500.0
Mite Lake Outfall Diversion Channel	364.71	95,000	464.24	150	503.5
rade Control Change	366.28	95,000	468.82	150	508.8
Hrst Street	366.80	95,000	471.46	150	510.6
rade Control Change	367.45	95,000	475.00	150	513.0
hannel Size Change	368.02	95,000	478.15	200	515.2
rade Control Point	368.40	95,000	480.25	200	516.4
TAMES COMMINE A LOTTING		95,000	480.50	200	516.9
Beach Street Riverside Drive	368.60 369.41	95,000	481.62	200	519.7

⁽¹⁾ Flow 148,000 cfs prior to Bear Creek Diversion.



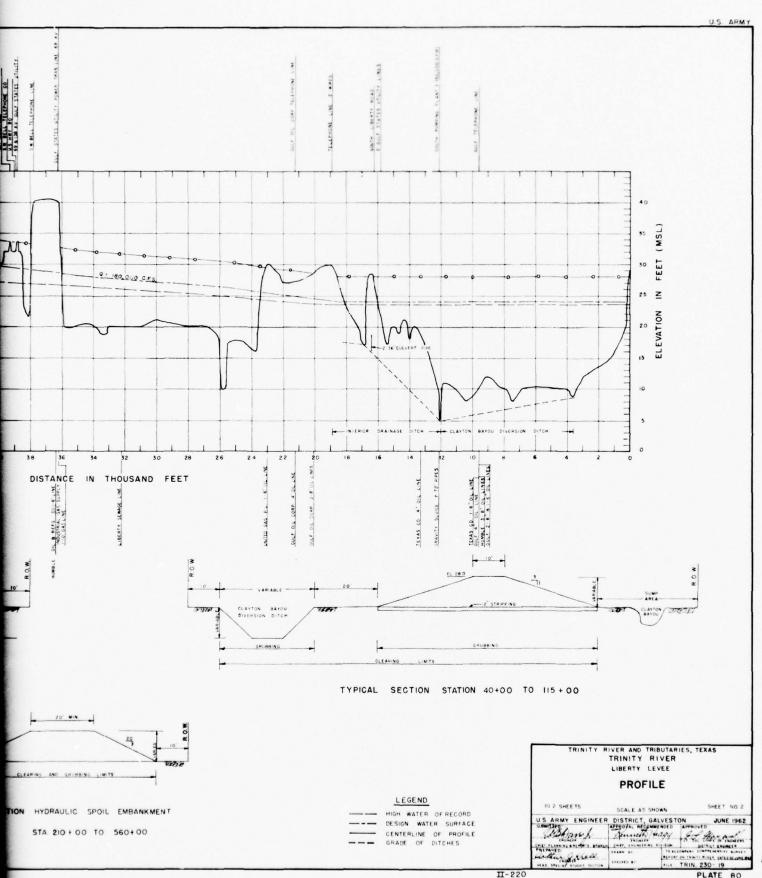


PLATE 80

TABLE 72

PERTINENT DESIGN DATA - RECOMMENDED RAILROAD BRIDGES MULTIPLE-PURPOSE CHANNEL

			-		Elevation: Maximum	Maximum	: Low st	Low steel elevation	ration
	:Channel:	Cha	Channel	Normal:	of:	high)	(ft-msl)	
Name of bridge	: mile :	bottom	tom	pool:	2 percent:	water	: Lift span		Flanking
		Width:	Grade	elevation:	ion:flow line:elev.(1):over channel	elev.(1)	over ch		spans
	•	feet):	(feet):(ft-ms1):((ft-msl):(ft-msl)		:(ft-ms1)	:Closed: Open	Open:	fixed)
Houston Ship Channel									
TENO R.R.	46.74	250	-13.0	16.0	17.1	26.3	29.3(2	1.79 (29.3
Missouri Pacific R.R.	52.57	250	- 5.6	16.0	20.0	34.5	38.2(3		38.2
GC&SF Rwy.	77.28	150	28.3	0.09	62.7	73.8	83.5(3))112.7	83.5
T&NO R.R.	91.93	150	42.7	0.09	74.1	91.0	0.46	124.1	0.46
Missouri Pacific R.R.	136.08	150	89.0	131.0(4)	133.0	133.0	142.7	183.0	142.7
Missouri Pacific R.R.	219.70	150	168.5	210.0	211.4	223.0	228.9(3	7501.4	228.9
SL&SW Rwy.	264.14	150	258.0	For design	data	refer to Tennessee	ennessee	Colony	Reservoir
Recommended Dallas Terminus									
T&NO R.R.	328,30	150	360.0	372	380.8	4.804	411.4	430.8	47.1.4
MKT R.R.	330.28	150	360.0	372	382.0	411.1	414.1	435.0	414.1
GC&SF Rwy.	331.09	150	360.0	372	382.5	412.2	416.6	432.5	416.6
T&P Rwy	333.66	150	371.5	396	397.6	417.2	428.8	9.744	428.8
Gifford Hill Gravel Co. R.R.	341.86	150	384.0	396	402.4	433.3	436.3	455.4	436.3
CRI&P R.R.	350.54	500	412.0	424	426.1	459.1	462.1	476.1	462.1

project flood design water surface in recommended or existing leveed floodways upstream of channel Refers to elevation of historical maximum high water below channel mile 322.0, and the standard mile 322.0 E

Recommended low steel will not adversely affect levee freeboard since standard project flood discharge will inundate rail on right bank, minimum base of rail elevation 28.2, for a distance of 12,800 feet. Based on maintaining existing grade of railroad at bridge crossing. Top of conservation storage in Livingston Reservoir which may be depleted to elevation 101.0. (5)

(£)

TABLE 73

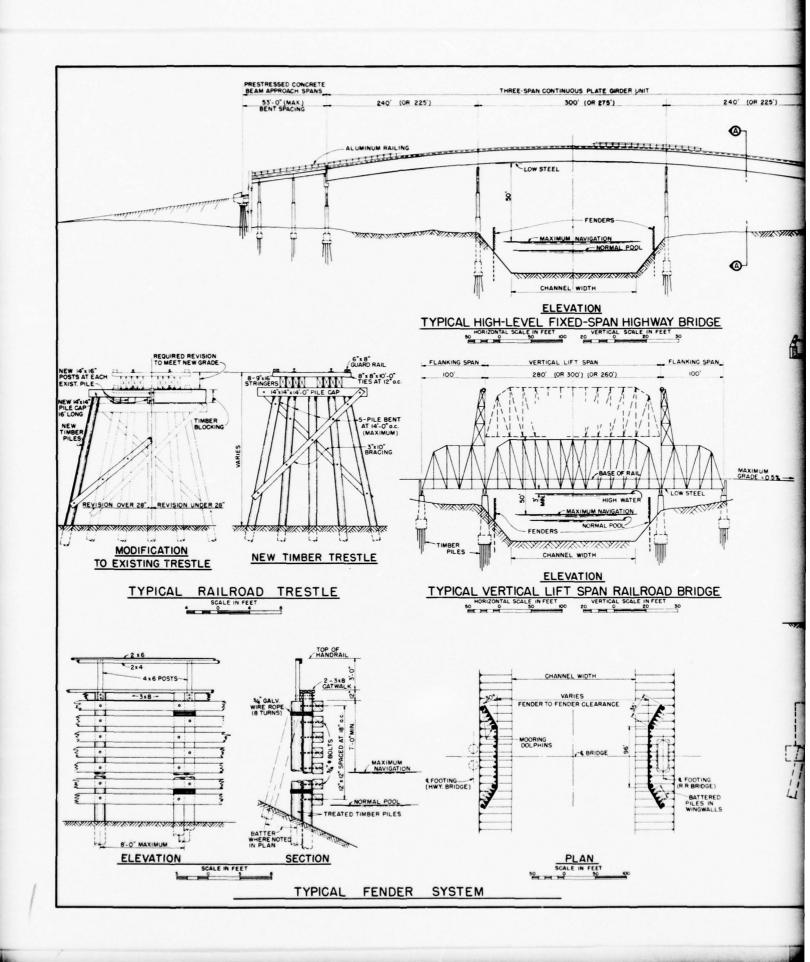
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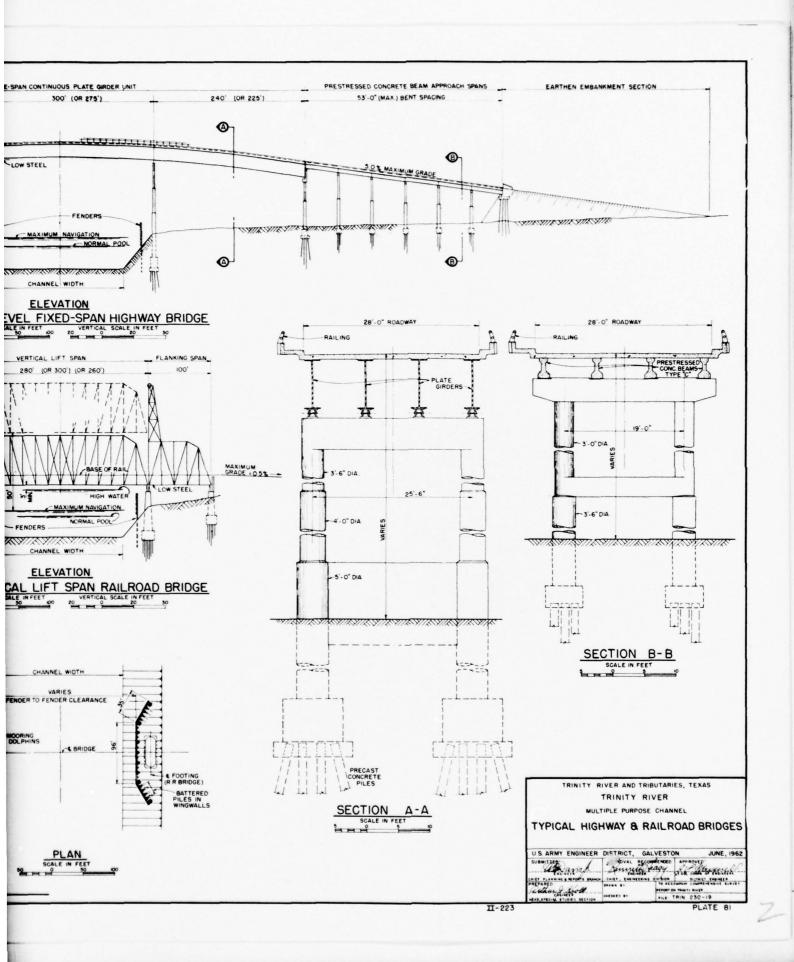
PERTINENT DESIGN DATA - RECOMMENDED HIGHWAY BRIDGES

MILTIPLE-PURPOSE CHANNEL

			Channel		: Elevation of		Design 3-span	Leveed	Toodvay
Name of bridge	Channel mile	Width	: Grade	elevation	: flow line		elevation	elevation	of leves
;		: (feet)	: (ft-ms])	(ft-ms1)	: (ft-ms1)	: (ft-ms1)	(ft-ms1)	: (L-181)	(feet)
Houston Ship Channel									
Interstate Highway 10 (Westbound)	30.36	150	-11.0	0.4	4.1	8.0	1:3		
Interstate Highway 10 (Eastbound)	30.37	150	-11.0	0.4	1.4	8.0	7.		
U. S. Highway 90 (Bastbound)	\$ 25	0,00	-13.0	16.0	17.1	20.00	67.1		
0. S. Highway 90 (Westbound)	3.4	25	-13.0	10.09	1.1.1	9.0	9,111		
U. S. Highest 50	91.76	28	1.5.7	0.09	0.47	0.16	124.0		
County Road (2)	86.86	150	89.0	101.0	102.0		152.0		
U. S. Highway 190	111.5	150	89.0	131.0	131.0	131.0	181.0		
State Highway 19	136.15	150	89.0	131.0	133.0	133.0	183.0		
State Highway 21	171.63	150	0.911	138.0	150.2	167.7	200.2		
State Highway 7	196.68	120	140.2	168.0	174.5	178.4	224.5		
Interstate Highway 35E	220.55	150	170.0	210.0	211.5	244.0	261.5		
U. S. Highway 28'	26.63	35	253.0	For design	data refer	to Tennessee Col	Colony Reservoir		
State Highest 1120	285.60	28	200	284.0	295.2	319.5	345.2		
State Highway 34	298.04	150	296.0	308.0	321.0	343.0	377.0	345.0	1,800
Malloy County Road	312.84	150	334.1	356.0	357.8	370.0	8.70 4	376.0	2,000
Belt Line Road	315.57	150	339.5	356.0	360.1	377.8	410.1	385.0	2,200
Dowdy Ferry Road (2)	319.92	150	348.1	372.0	373.8	396.0	423.B		
Proposed Dallas Terminus									
	**								
State Highway Loop 12 (Eastbound)	8 8	120	360.0	372.0	379.2	9. 101	2.62	0.00	2,150
Tatement Highway Loop 12 (Westbound)	208.15	25	2000	372.0	380.8	0.00	130.8 130.8	112.7	2,13
12	28.47	2.5	360.0	375.0	380.8	108.1	430.8	412.7	2,000
	330.65	120	360.0	372.0	382.3	411.6	432.3	415.6	2,400
Corinth Street	331.41	18	363.8	396.0	397.0	413.5	447.0	425.7	2,300
Cadiz Street	335.22	150	366.6	36°C	397.2	414.8	447.2	427.2	1,950
Interstate Highway 35E	332.28	120	366.8	396.0	397.2	414.9	147.2	4.7.4	5,000
Houston Street	332.61	25	388.0	9,9	391.2	415.5	11.7.3	4 ac.	2,000
Commence Street North Toll Mond	333.12	25	30%	200	391.3	410.3	147.3	130.7	2,320
Continental Street	333.93	295	372.5	20.90	397.8	417.7	17.8	430.3	1.900
Sylvan Road	334.89	120	375.7	396.0	398.5	419.2	148.2	431.4	2,600
Hampton Road	336.33	120	380.7	396.0	399.5	421.4	2.644	4.464	3,070
Westmoreland Road (2)	337.26	150	383.9	396.0	400.2	422.9	450.2	433.6	2,900
State Highway Loop 12	340.39	150	384.0	3800	20.5	430.0	2.0	431.1	2,100
Meyers Hoad	¥.7.5	8 8	#03.x	0.424	100.0	20.0	175.0	100	2,100
State Utchian 260	345.65	88	10.00	0.424	1.62.1	150 5	1. C. Y.	1,000	3,500
To M Road 157 (Northhampd)	25.00	8 8	431.7	0.654	453.0	1,60.8	0.503	M63.8	1.600
F. M. Boad 157 (Southbound)	354.01	888	431.7	452.0	453.0	8.694	503.0	163.8	1.600
Arlington-Bedford Road	357.00	88	439.7	452.0	453.2	4.78.2	503.2	482.3	3,000
Arlington-Smithfield Road	359.95	800	0.04	455.0	453.7	483.8	503.7	8.784	3,000
U. S. Highway Loop 820 (3)	362.11	250	9.964	1,80.0	181.0	193.7	531.0		
Handley-Ederville Road	362.70	120	7.27	0.084	481.0	496.3	531.0	500.3	2,300
Proposed Fort Worth Terminus									
East Pirst Street	366.80	150	471.5	480.0	None	510.6	513.6	514.6	1,050
Beach Street	368.60	800	480.5			516.9	519.9	550.9	1,700
Riverside Drive (Northbound)	369.41	500	97.184			519.7	225.7	523.7	1,120
Riverside Drive (Southbound)	369.41	88	97.184			519.7	28.7	523.7	1,120

⁽¹⁾ Refers to elevation of historical maximum high vater below channel mile 322.0 and the standard project flood design water surface in proposed or existing leveed floodways upstream of channel mile 322.0
(2) Under construction as of January 1962.
(3) Under construction Rebruary 1962. Requires new bridge on land-cut channel for both the north-and southbound lanes.

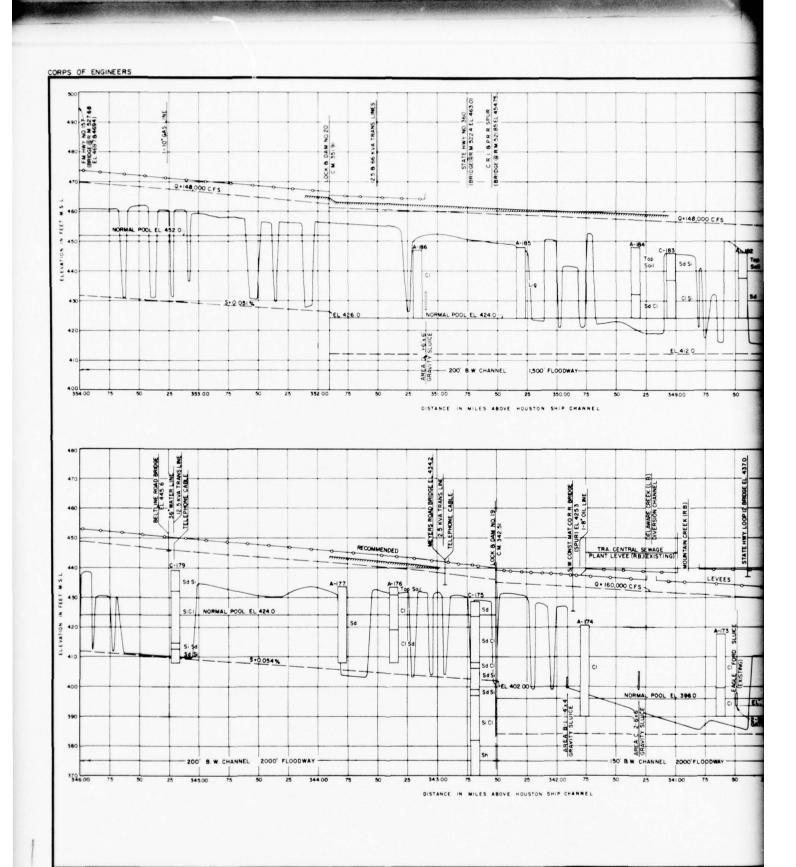




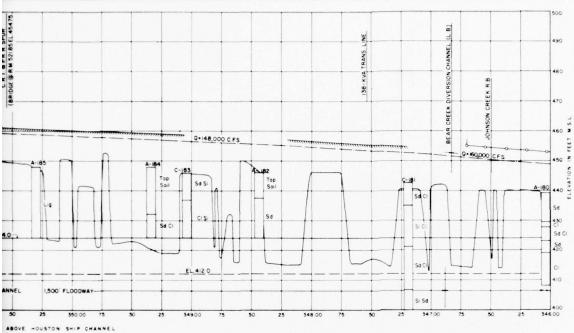
P

164. WATER SURFACE PROFILES - MULTIPLE-PURPOSE CHANNEL.-

- a. Trinity River below Five Mile Creek. Backwater studies were made for the improved channel for various regulated flows including the 2 percent flood discharge, using a channel roughness coefficient of 0.030 in the Manning formula. The minimum level in each navigation pool was assumed to be one foot above normal pool during the passage of these flows. The mean channel velocity for the operating and 2 percent discharge would vary from 0.4 to 4.6 miles per hour with Tennessee Colony and Livingston Reservoirs at or above conservation level. However, in extreme cases, when the reservoirs would be empty and the navigation pools at normal (minimum) level, velocities in the portion of the channels in the reservoirs would be slightly higher. Plates 66 through 69 show the water surface profile for the 2 percent flood discharge for the limits of navigation under improved conditions.
- b. Trinity River and West Fork above Five Mile Creek.-Backwater studies for the multiple-purpose channel upstream from Five Mile Creek were based on the assumption that the flows would be confined within levees (within the designated floodway limits) having a distance between centerlines of levees varying from a minimum of 1,050 feet to a maximum of 3,000 feet. Where levees are not provided on both banks in the recommended plan of improvement, this assumption would permit construction of additional levees where required, or other development in the remaining flood plain without encroachment on the capacity of the designed floodway. Water surface profiles for the design flood discharge were developed for the improved floodway, using roughness coefficients of 0.030 in the Manning formula for the channel, and 0.070 for the overbank (berms between channel and levees). Plates 82 through 85 show the design water surface profile for the standard project flood discharge above Five Mile Creek under improved conditions.



U.S. ARMY



4370 E LINE 1-8 OLLINE (SPUR) EL 4253 K VA TRANS 60-KVA TRANS 6 GASL

STATE HWY LOOP IS CONFLUENCE WITH ELM FORK (LB)
TRINITY RIVER MILE 505.48 - C.M. 338.80 PLANT LEVEE (RB)(EXISTING) EXISTING LEVEE LEVEES Q . 160,000 CFS A-173 ON C-171
Si Sd
SdCI -172 Sd C CI CI Sd Sd Gr NORMAL POOL EL 396.0 SICI SLUICE 2-54"X 54" SLUICE

2000 FLOODWAY

340.00

25

339 00

34100

ABOVE HOUSTON SHIP CHANNEL

342 00

150' BW CHANNEL

25

BORING LEGEND

LABORATORY CLASSIFICATION

M Silty Sands, Sand-Silt mixtures

- SM Sitty Sonds, Sand-Sitt mixtures
 ML Inorganic Sitts and very fine
 Sonds, Rock Flour, Sitty or
 Cloyey fine Sonds or Cloyey
 Sitts with slight plosticity
 CL Inorganic Clays of law plasticity,
 Gravelly Clays, Sandy Clays,
 Sitty Clays, Leon Clays
 CH Inorganic Clays of the plasticity
 Consecution Clays of the Program of the Program of Clays of the Program of Clays of the plasticity
 CH Inorganic Clays of the plasticity
- CH Inorganic Clays of high plasticity, Fat Clays

Gr Gravel or Gravelly Sd Sand or Sandy Si Silt or Silty

- CI Clay or Clayey FE Fuller's Earth SS Sandstone SiS Siltstone

- CS Claystone
 Sh Shale or Shaly
 Lig Lignite
- Ls Limestone Hard
- BA Machine Auger Boring, B"diameter 6C Core Boring,6" diameter WT. Water Table

- H.D. Texas Highway Dept boring
- R D Dallas County Road District No.1 Borings

Absence of ground water levels opposite being logs does not mean necessarily that ground water will not be encountered at the locations or within the vertical reaches of the borings.

Figures to the right of boring logs are water contents in percent of the dry

weight

NOTES

measured from centerline of levees, or from centerline of levee to natural bank or fill area Channel side slopes are I vertical on 2 horizontal.

Levee side slopes are I vertical on 2‡ horizontal All bridges shown are existing structures. Eleval of bridges refer to existing low steel elevations.

LEGEND

DESIGN WATER SURFACE

LEVEE, RIGHT BANK

LEVEE, LEFT BANK

CENTERLINE PROFILE BOTTOM GRADE

RECOMMENDED FILL AREAS, LEFT BANK

RECOMMENDED FILL AREAS, RIGHT BANK

BOTTOM WIDTH

LEFT BANK L.B.

RIGHT BANK RB

TRINITY RIVER AND TRIBUTARIES, TEXAS WEST FORK MULTIPLE PURPOSE CHANNEL

DETAILED PROFILES

SHET NO.

SCALES AS SHOWN

ARMY ENGINEER DISTRICT, FORT WORTH

APPROVED THE STATE OF THE SHEET NO.

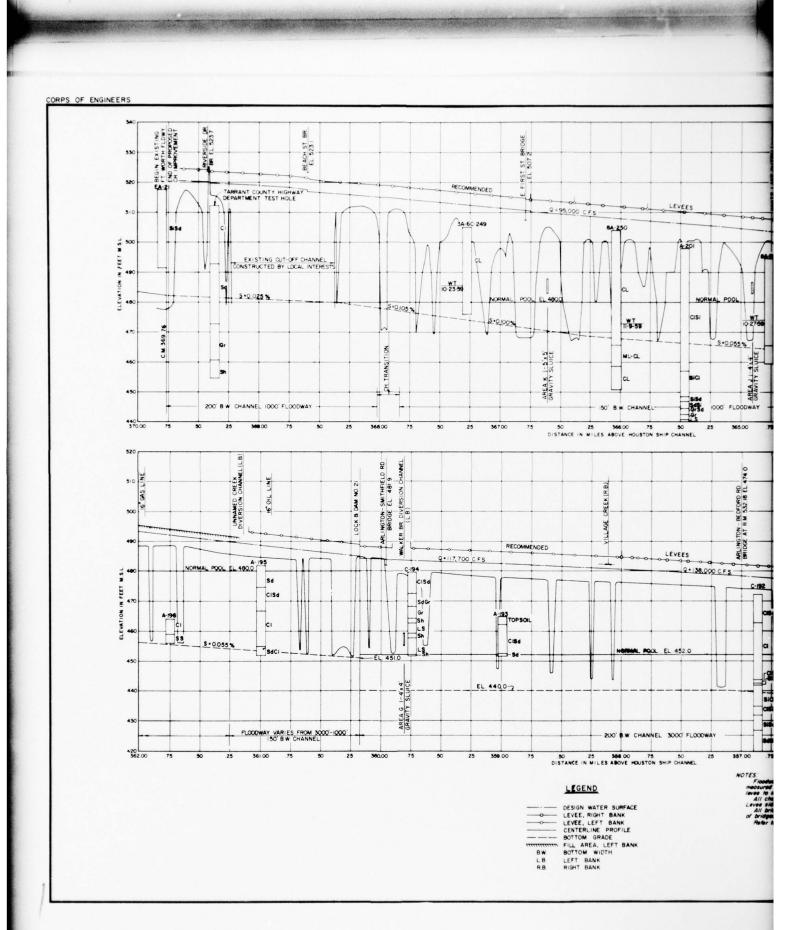
APPROVED THE SHEET NO.

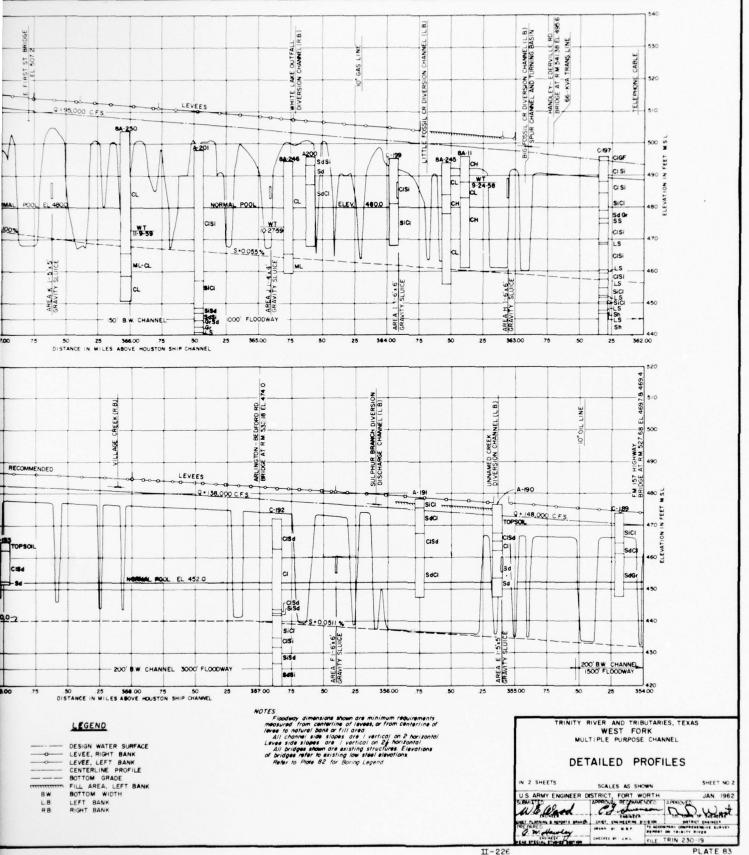
FOR THE SHEET NO.

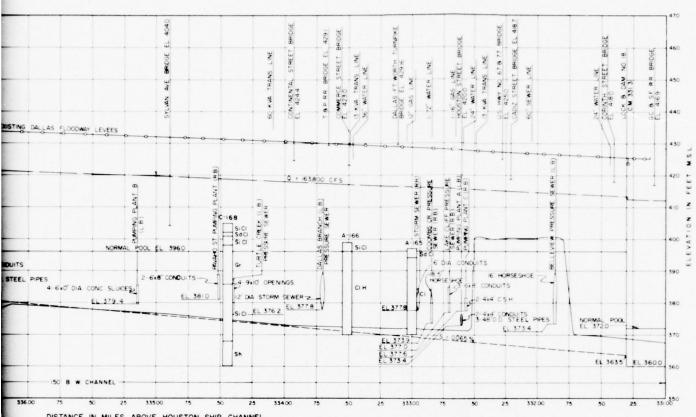
FOR THE SHEET NO.

TO ACCOUNT TO MINISTRA THE SHEET NO.

TO ACCOUNT TO MINISTRA THE SHEET NO. NE Gland







DISTANCE IN MILES ABOVE HOUSTON SHIP CHANNEL

LEGEND

DESIGN WATER SURFACE LEVEE, RIGHT BANK LEVEE, LEFT BANK CENTERLINE PROFILE BOTTOM GRADE LEFT BANK ___ --LB BOTTOM WIDTH B.W. RB RIGHT BANK

NOTES

All channel side slopes are I vertical on 2 horizontal.

All bridges should are existing structures. Elevations of bridges refer to existing low steel elevations.
Pumping plants and drainage structures shown are those of the existing Datios Floodway.

Refer to plate 32 for boring legend.

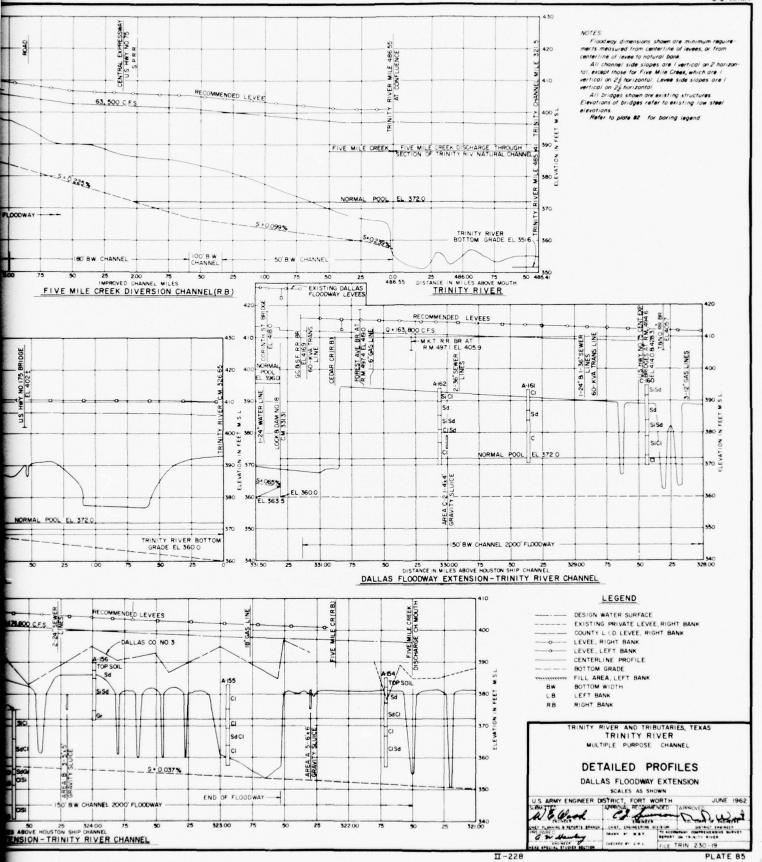
TRINITY RIVER AND TRIBUTARIES, TEXAS TRINITY RIVER

DETAILED PROFILE

DALLAS PLU

SCALES AS SHOWN
US ARMY ENGINEER DISTRICT, FORT WORTH

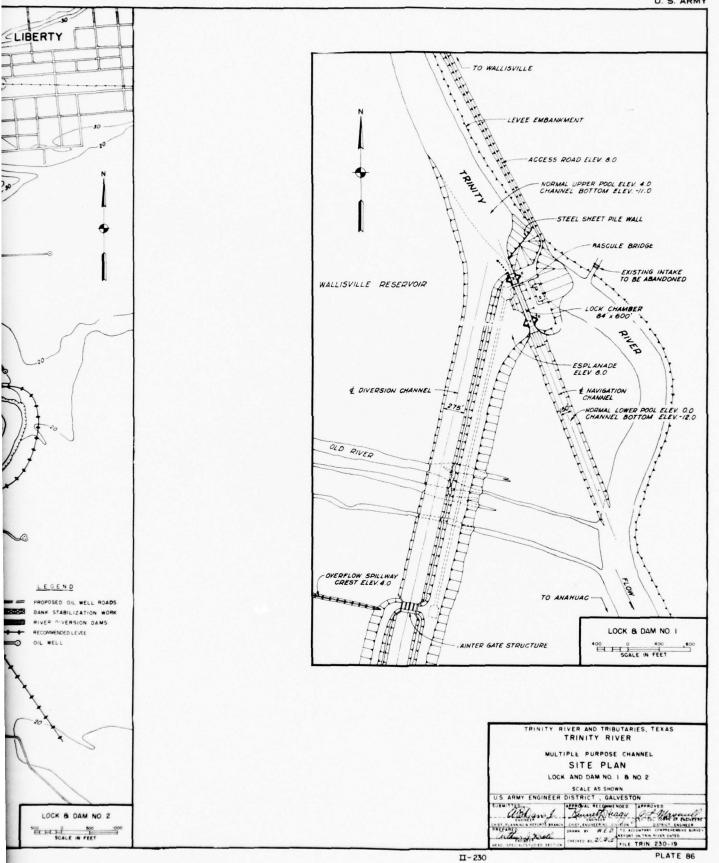
LINE BOOK BECAUSE OF THE CONTROL OF THE CONT

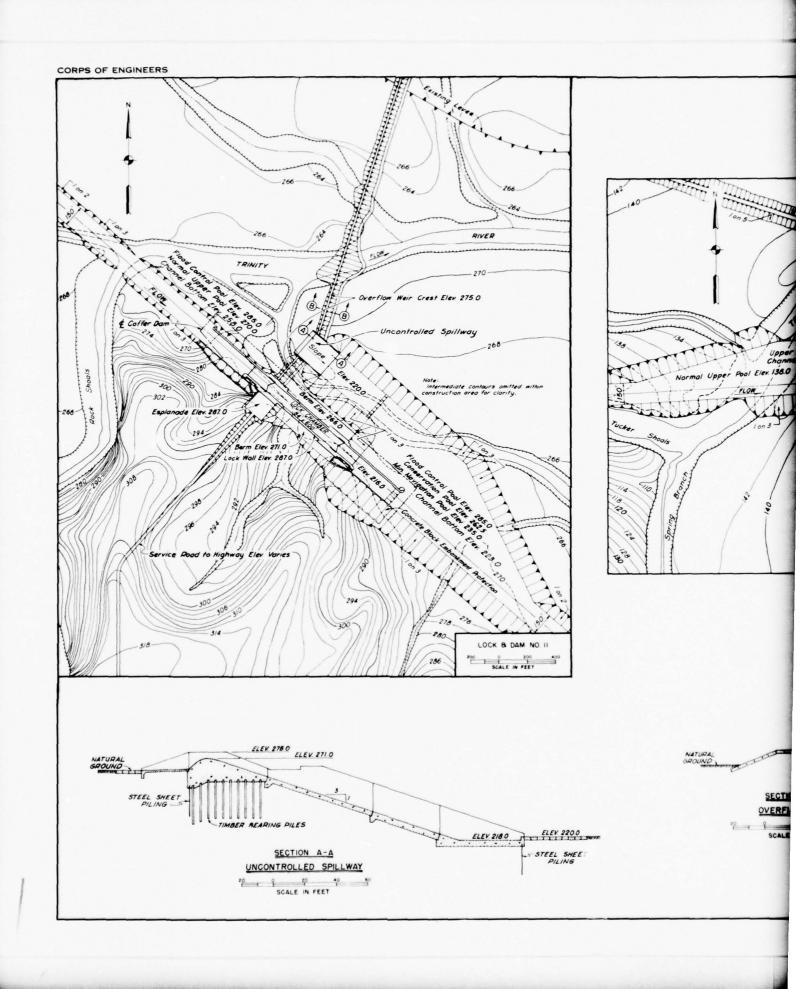


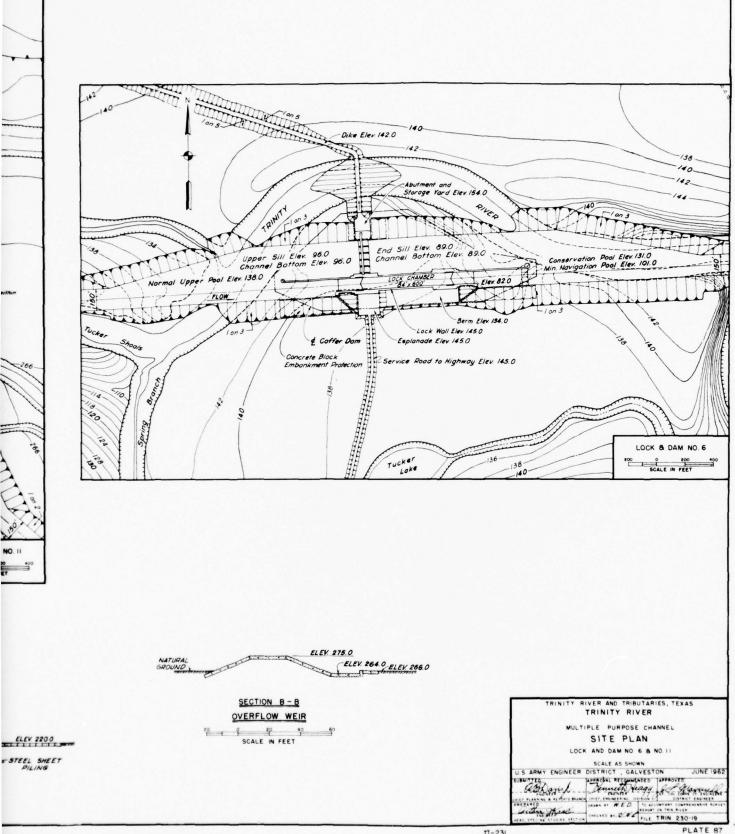
- 165. NAVIGATION LOCKS. A total of 23 navigation locks would be required to overcome the total fall of 480 feet in the recommended multiple-purpose channel. All of the locks, except Lock No. 1, would be equipped with miter gates. Lock No. 1, with a maximum lift of 4 feet, is located where a reversal of head may occur and would be equipped with sector gates. No filling and emptying system would be required for Lock No. 1 as filling and emptying would be accomplished by end filling and emptying through the gates. The remainder of the locks provide side port filling and emptying systems which were designed in accordance with the "Arkansas River Multiple-Purpose Project, Arkansas River and Tributaries, Project Design Memorandum No. 3, Navigation Lock, Part I Criteria." Typcial navigation locksites and lock and dam details are shown on plates 86 through 93.
- 166. For the 84- X 600-foot locks a side port filling system is proposed in each lock wall. The filling system would consist of a 12- X 12-foot culvert with valves of reversed tainter gates, 8 intake manifolds, 20 lock chamber ports located in the downstream two-thirds of the chamber and staggered with those on the opposite wall, and 6 discharge manifolds. The locks above Dallas would also have a side port filling system consisting of an 8- X 8-foot culvert with 6 intake manifolds, 13 lock chamber ports and 4 discharge manifolds located in each wall.
- 167. The approximate lock filling or emptying time for the range of lifts of the 84- X 600-foot locks under consideration was computed by the formula T=m / H/2g given in EM lll0-2-1604. In this formula, T is the filling or emptying time in seconds; T the design lift; and T a constant with an assumed value of 900 considered applicable for shallow draft barge locks. Based on this formula the tentative filling and emptying time varies from 5.5 minutes for a l0-foot lift to l0.5 minutes for a 40-foot lift, as shown in the following tabulation:

TENTATIVE LOCK FILLING AND EMPTYING TIME

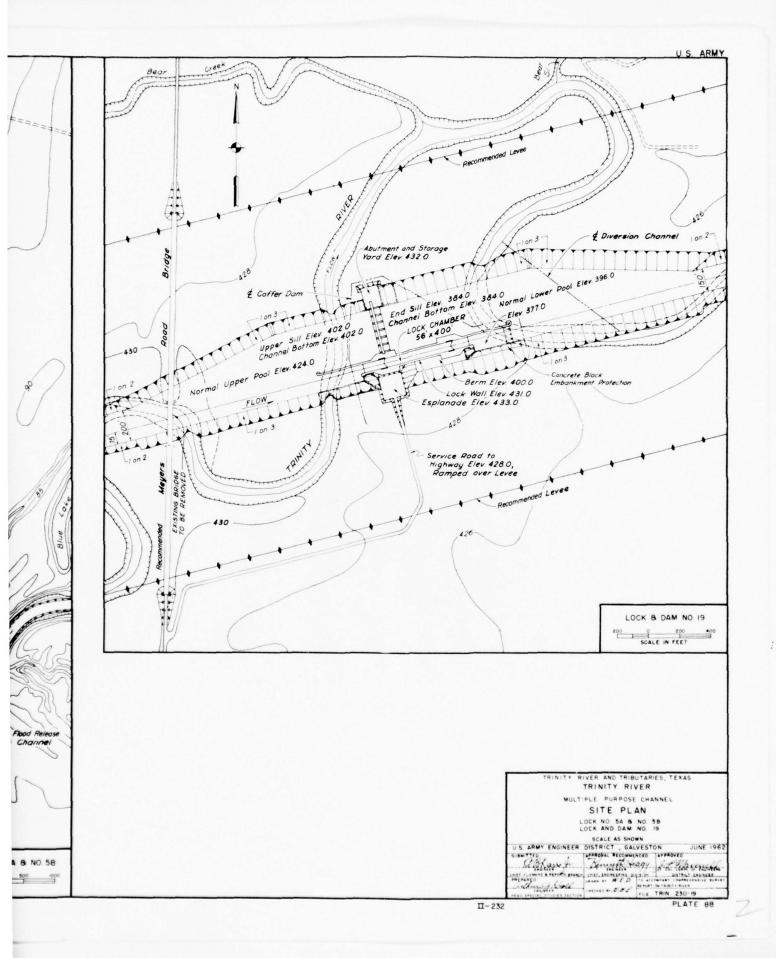
Lift (H)	: Filling time (T) : (minutes)	: Selected time : (minutes)
40	10.33	10.5
35	9.50	9.5
30 25 20	9.08	9.0
25	8.25	8.25
20	7.40	7.5
15	6.56	6.5
10	5.33	5.5

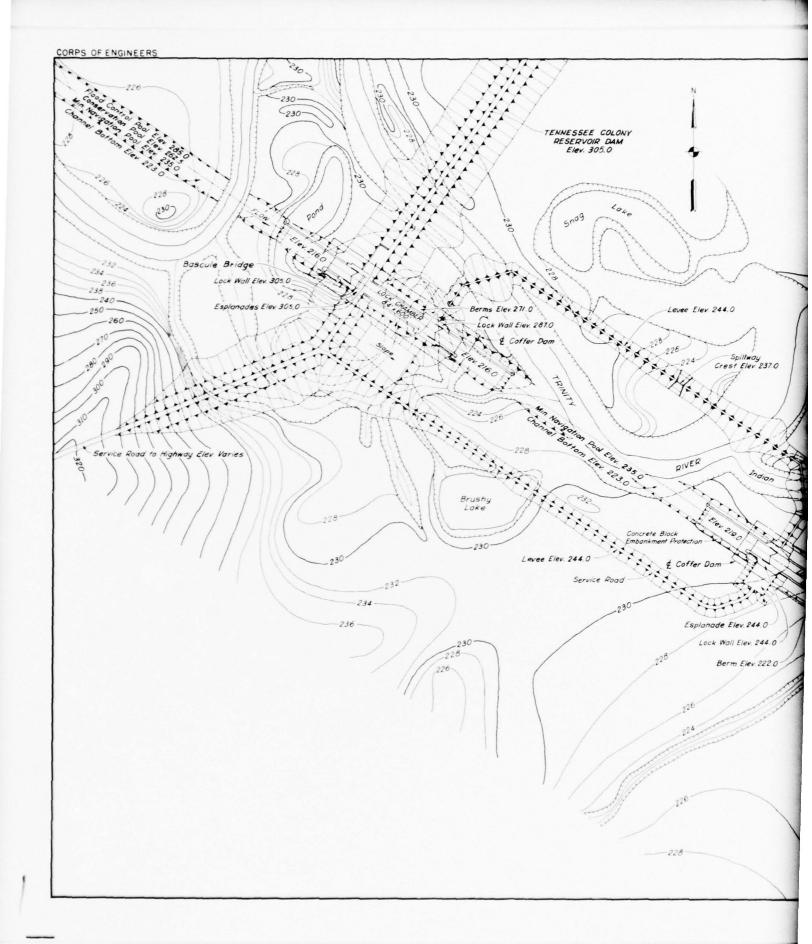


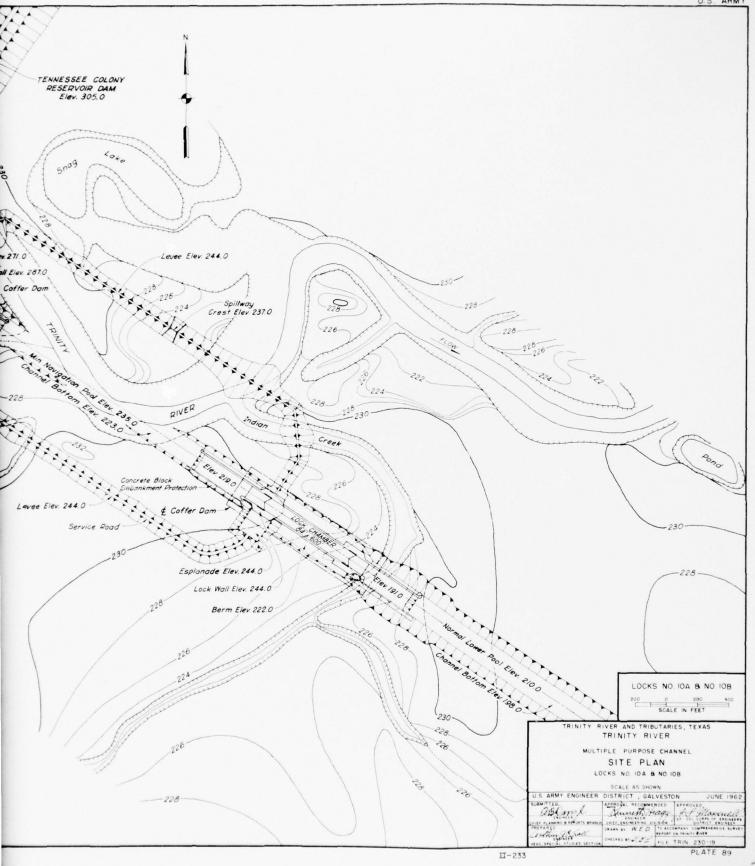


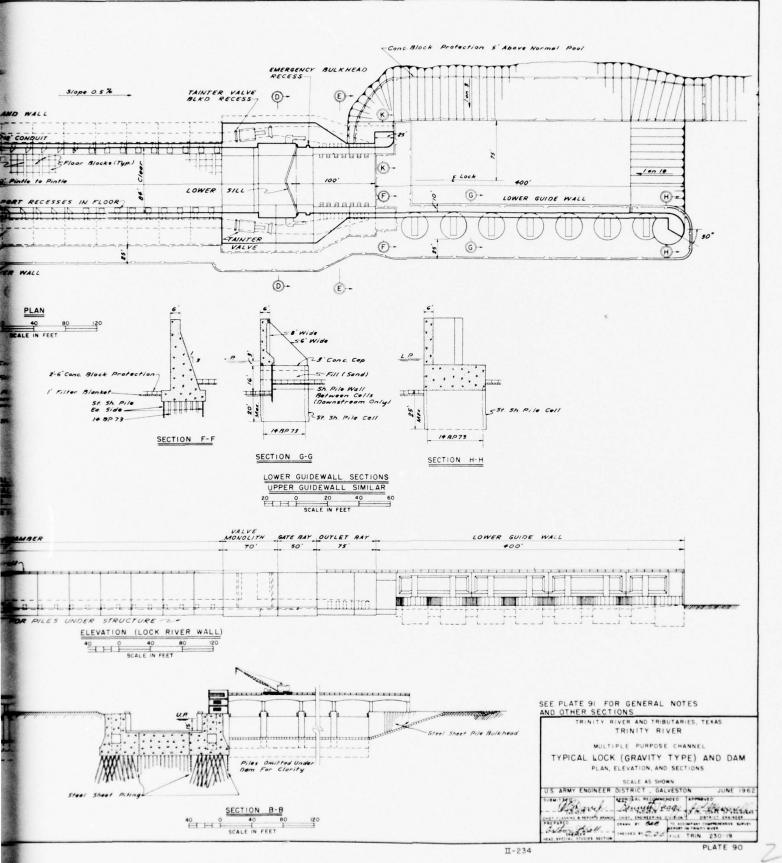


11-231



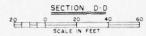


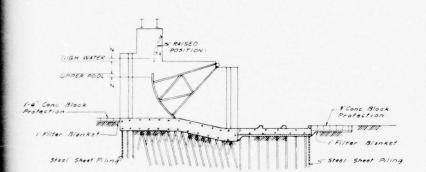


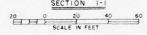


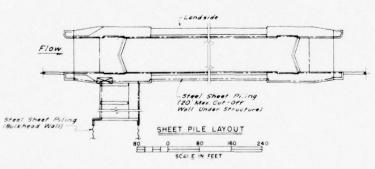
SECTION OF LOWER SILL
O O 20 40
SCALE IN FEET

GITE RECESS UP I' Filter Blanket - Steel Sheet Piling











ION OF LOWER SILL 20 40 60 SCALE IN FEET

GENERAL NOTES LOCKS

- I THE 81', 600' LOCK SHOWN ON PLATES 90 AND 91 IS
 REPRESENTATIVE OF LOCKS 2, 3, 4, 7, 8, 9, 104,
 IZ, 13, 14, 15, 6, AND 17
 2 OTHER LOCKS ARE SIMILAR EXCEPT FOR THE
 FOLLOWING FEATURES:
 LOCKS 84, 6, 104, AND 11 ARE U-FRAME
 LOCKS (WITHOUT BEARING PILES, SEE
 PRINES 32 AND 108 (REFER TO PLATES 92
 AND 93)
 LOCK SS, 8 AND 108 (REFER TO PLATES 92
 AND SS, 11 COMMERCE IS APPROXIMATELY 20 FEET
 LONGER TO ACCOMMODATE THE GATE GUARD
 20 A SINGLE LANE BASCULE BRIDGE IS PROVIDED.
 30 LOCK WALLS AT DAM SECTION ARE EXTENDED
 TO PROVIDE RETAINING WALLS UPPER GATE
 HEIGHTS ARE ADJUSTED ACCORDINGLY
 LOCKS 18, 19, 20, AND 21-SMALLER LOCKS
 (56' & 400' CHAMBER IN LIEU OF 81' & 600'
 AND 300-FOOT GUIDEWALL LENGTHS IN
 LIEU OF 400-FOOT.
 3 THE FOLLOWING CRITERIA APPLIES TO LOCKS 2
 THROUGH 21, EXCEPT AS NOTED.
 DEPTH AT SILLS-15 FEET BELOW RESPECTIVE
 POOLS.
 LODD OF WALLS-7 FEET ABOVE NORMAL UPPER
 POOL WILLS-17 FEET ABOVE NORMAL UPPER
 POOL WILLS-18 FEET BELOW RESPECTIVE
 ROOL WHICKVER IS HIGHER, EXCEPT FOR 58 É 108.
 BOTTOM OF CHAMBER FLOOR-18 FEET
 BELOW LOWER POOL.
 BOTTOM OF CHAMBER FLOOR-18 FEET
 BELOW LOWER POOL.
 CHEET UPPER GATES AT LOCKS 58 AND TOB.
 THE FOLLOWING CRITERIA IS USED WHERE
 APPLICABLE
 SECON LOCKS IN FOOT BELOW TOP OF
 SILL TO 2 FEET ABOVE UPPER POOL.
 EXCEPT UPPER GATES AT LOCKS 58 AND TOB.
 THE FOLLOWING CRITERIA IS USED WHERE
 APPLICABLE
 SERVING FILE CUTOFF WALL LENGTH-20
 FREE MAILMONG CRITERIA IS USED WHERE
 NORMAL POOL ON EARTH SLOPES OPPOSITE
 GUIDE WALLS AND AT BASE OF WALLS AS
 SHOWN

 5. GUIDE WALLS AND AT BASE OF WALLS AS
 SHOWN

 5. GUIDE WALLS AND AT BASE OF WALLS AS
 SHOWN

 5. GUIDE WALLS AND AT BASE OF WALLS AS
 SHOWN

 5. GUIDE WALL AND GUARD WALL SECTIONS ARE
 TYPICAL FOR LOCKS 2 THROUGH 21.

- 5. GUIDE WALL AND GUARD WALL SECTIONS ARE TYPICAL FOR LOCKS 2 THROUGH 21 GRAVITY TYPE WALLS ON BEARING PILES ARE DESIGNED TO BE INDEPENDENTLY STABLE.

- 1. THE CONTROL DAM SHOWN IS REPRESENTATIVE OF DAMS 2, 3, 4, 6, 7, 8, 9, 12, 13, 14, 15, 16, 17, 18, 19, 20, AND 21.
- 2 CONTROL DAMS ARE NOT REQUIRED AT SITES 54, 58, 104, AND 108
- 3 A CONCRETE SPILLWAY IS PROVIDED FOR DAM
- 11.

 1 THE FOLLOWING CRITERIA APPLIES TO ALL CONTROL DAMS.

 a WIDTH OF GATES 40 FEET.

 b WIDTH OF DIERS 8 FEET.

 c WIDTH OF MONOLITHS 48 FEET.

 i TOP OF GATES 2 FEET ABOVE UPPER POOL.

 i TOP OF PIERS, ABUTMENTS AND STORAGE TARD 2 FEET ABOVE WIPPER POOL.

 FILL ELEVATION 12 FEET BELOW UPPER POOL.

 ELEVATION OF DESIGN APPROACH CHANNEL.

 BOTTOM, WHICHEVER IS THE LOWER ELEVATION.

TRINITY RIVER AND TRIBUTARIES, TEXAS TRINITY RIVER

MULTIPLE PURPOSE CHANNEL

TYPICAL LOCK (GRAVITY TYPE) AND DAM SECTIONS

US ARMY ENGINEER DISTRICT, GALVESTON JUNE 1962
SUBMITTED

TERPORAL RECOPUESED APPROVED

THE CAMPON STETEM PARKS CHEE, DEVINE DISTRICT RESPECTANCE

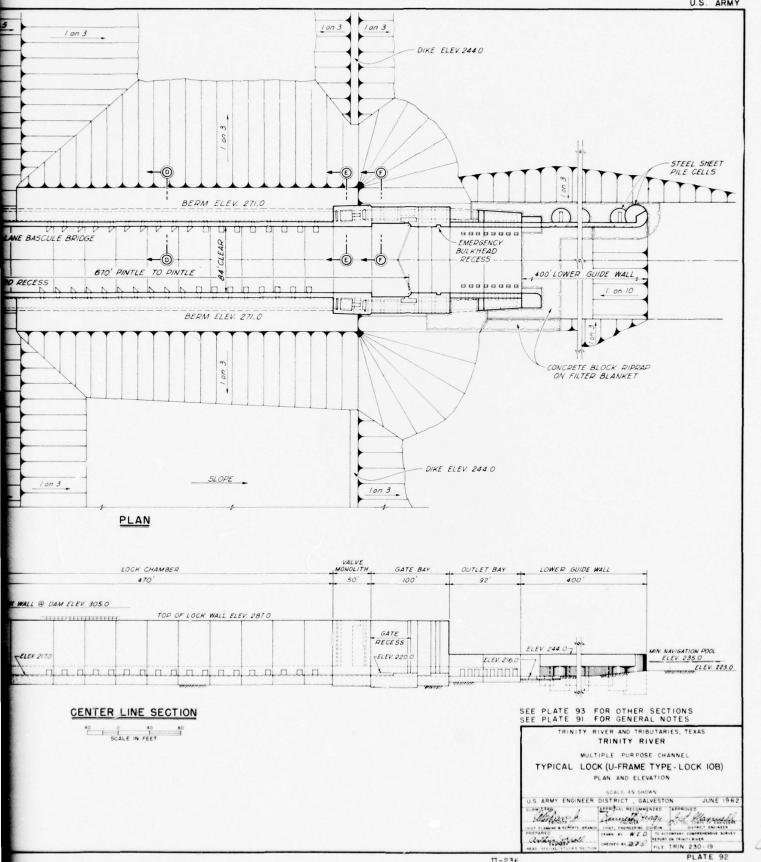
THE CAMPON STETEM PARKS CHEE, DEVINE DISTRICT RESPECTANCE

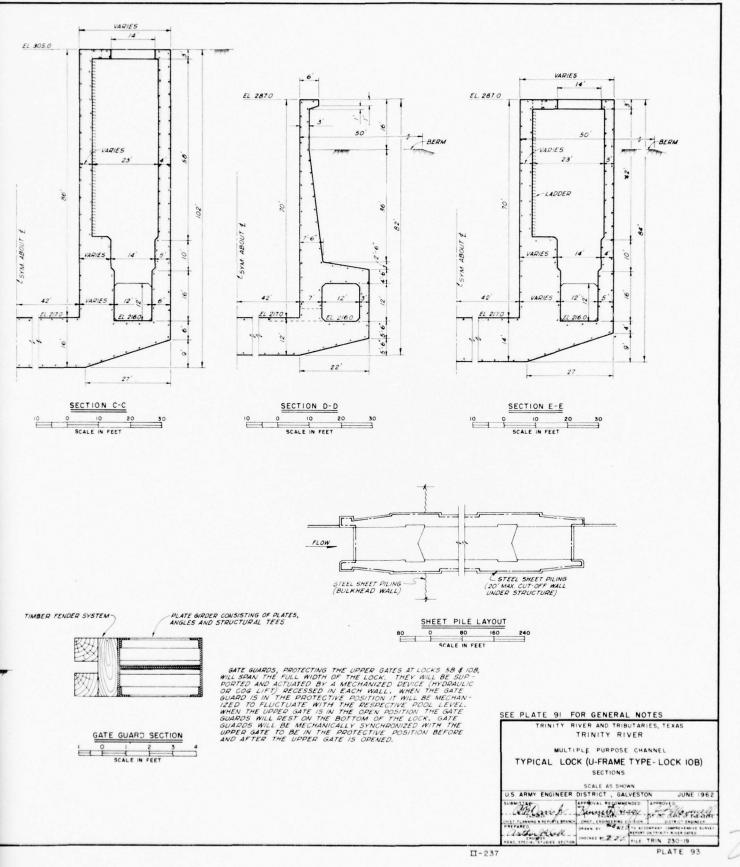
THE CAMPON STETEM PARKS CHEE, DEVINE DISTRICT RESPECTANCE

THE TRIN 230-19

THE TRIN 230-19







- 168. NAVIGATION DAMS. A total of 18 navigation dams would be required in connection with the canalized Trinity River. All of the navigation dams, with the exception of Dam No. 11, would be withinchannel dams of the movable, non-navigable type. These dams, placed adjacent to the locks, would consist of sills, placed on grade with the flood discharge channel, surmounted by tainter gates. The top elevation of the tainter gates would be two feet above the level of the upper navigation pool. The required cross-sectional area of the gates was determined by the D'Aubisson formula for the condition that the structure when passing bankfull flows would not raise the water surface more than 0.5 feet above the stage that would exist without the structure. Discharges greater than bankfull capacity would overflow the banks and a part of the flow would occur in the flood plain. Due to the submergence of the sill and the cross-sectional area of the gates, no jump was formed at the dam and therefore, apron design or length of riprap required below the apron presented no particular problems. The pertinent hydraulic data relating to the navigation dams are shown in table 74.
- 169. Navigation Dam No. 11, located within the flood-control pool of Tennessee Colony Reservoir, would be a fixed non-navigable dam. The structure would extend across the entire flood plain and would consist of a spillway with crest at elevation 275 and a total length of 5,700 feet, including a 200-foot notch with crest at elevation 271.0. The notch would have a capacity of 4,800 second-feet which is adequate to pass the average annual discharge of about 3,600 second-feet plus about 500 second-feet of return flow from upstream sources. Flood inflows to the reservoir would pass over the uncontrolled spillway to the lower conservation and flood-control pool. With one foot overflow, the spillway would pass a flow of 23,000 second-feet, which is approximately equal to the operating discharge of the multiple-purpose channel at Lock and Dam No. 12. Accordingly, it is considered that the spillway would have no appreciable effect on the passage of flood flows.

TABLE 74

HYDRAULIC DATA - NAVIGATION DAMS MULTIPLE-PURPOSE CHANNEL

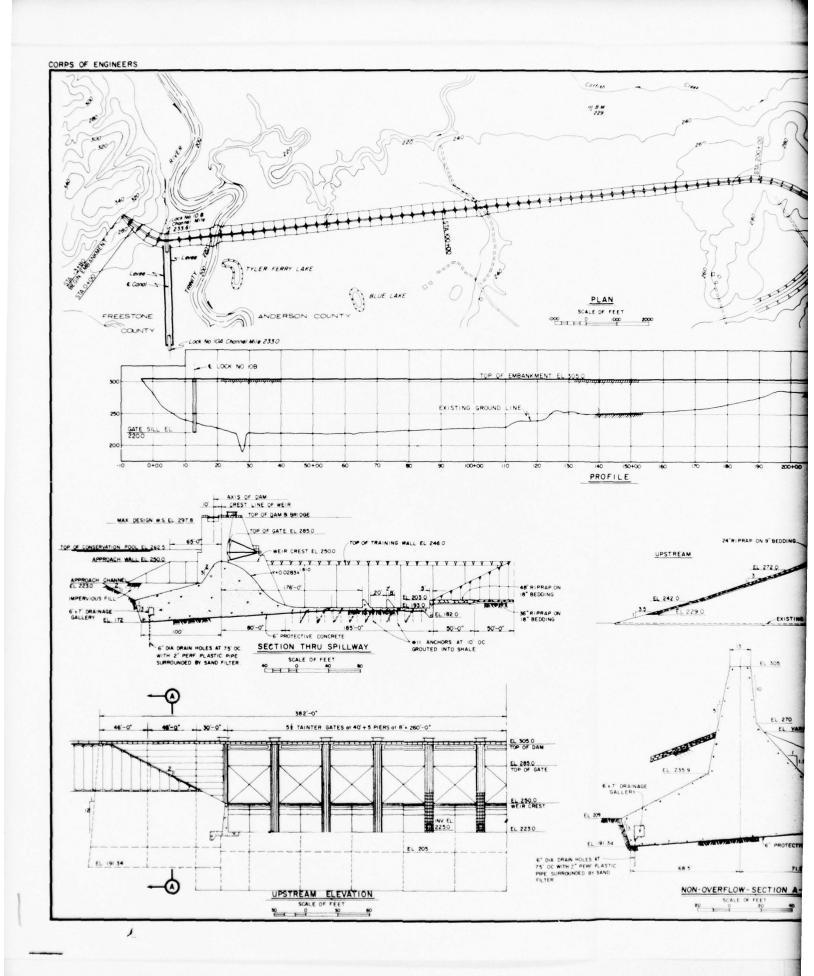
18 4 T	
:Riprap: :length :(feet)	288 - 1488 - 188
:Apron :Ripra :length:lengt :(feet):(feet	67 67 67 68 67 67 67 67 67 67 67 67 67 67 67 67 67
14 2	451.0 426.0 402.0 363.5 334.0 332.0 322.0 278.0 258.0 152.0 152.0 150.0 26.0
gates Size (feet)	100x31 100x28 100x24 100x34.5 100x24 100x24 100x24 100x44 100x46 100x44 100x46 100x46 100x46 100x46 100x46 100x46 100x46 100x46 100x46 100x46 100x46 100x46 100x46 100x46
: Tainter:	000000000000000000000000000000000000000
ge (cfs) : Bankfull :capacity(1)	86,000 64,000 64,000 68,000 68,000 68,000 68,000 68,000 68,000 68,000 68,000 68,000 68,000 68,000 68,000 68,000 68,000
Lift: Discharge in :Min. design: B feet: capacity :ca	15,000 15,000 27,000 27,000 27,000 32,000 32,000 45,000 45,000 45,000 45,000
Lift: in: feet:	1502-136888888888888888888888888888888888888
<pre>elevation:Lift: t-msl) : in : r: Upper :feet:</pre>	1,50 1,38 1,38 1,38 1,38 1,38 1,50 1,50 1,50 1,50 1,50 1,50 1,50 1,50
Pool eleva (ft-msl Lower: Up	192 193 194 196
: Channel : mile :	360.17 342.52 342.52 342.52 342.52 311.65 306.33 206.34 207.55 1083.92 147.92 147.93 147.93 147.95 14.65 147.95 14.65 147.95
Dam number	100000000000000000000000000000000000000

Bankfull capacity immediately downstream from dam. See plate 87 for design of Dam No. 11. Storage reservoirs, no navigation dams. 300

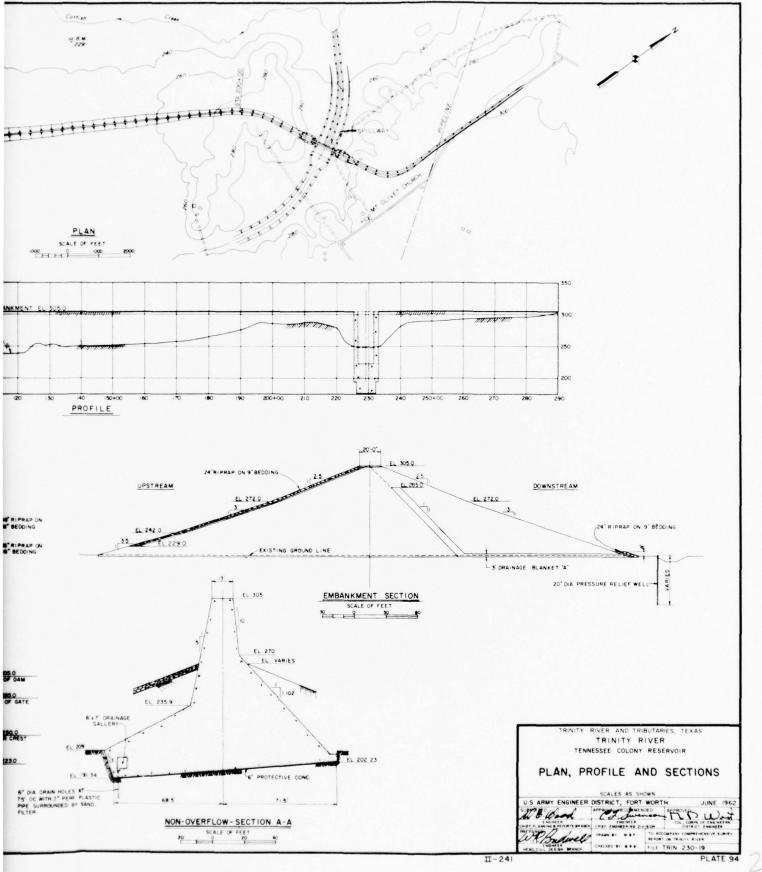
170. MULTI-PURPOSE DAMS. - Dams are recommended at the Tennessee Colony site on the Trinity River at river mile 339.2 (improved channel mile 233.61), Lakeview site on Mountain Creek, river mile 7.2, Aubrey site on Elm Fork, river mile 60.0, and the Roanoke site on Denton Creek, river mile 31.4.

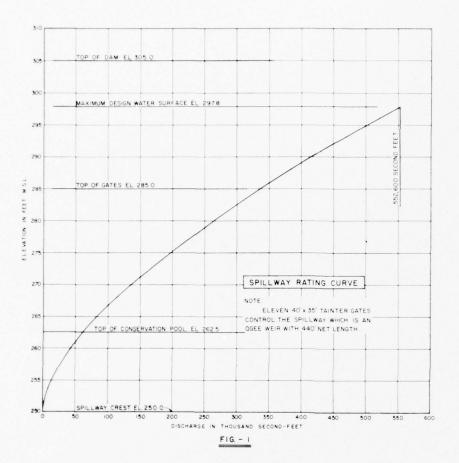
171. TENNESSEE COLONY DAM .-

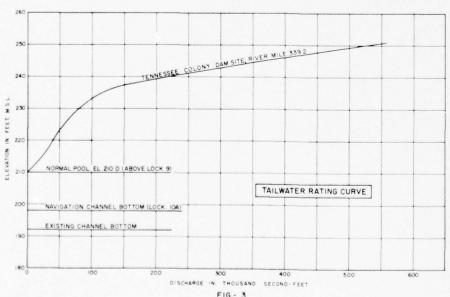
- a. Spillway. The earthen dam would be located on the Trinity River at river mile 339.2 with the spillway on the left bank. The spillway would consist of an ogee weir with an underdesigned crest at elevation 250.0 controlled by eleven 40- X 35-foot tainter gates separated by 8-foot piers. Details of the spillway and stilling basin are shown on plate 94. Under conditions of the spillway design discharge (552,600 second-feet through the spillway) the reservoir level would be at elevation 297.8. The proposed Tennessee Colony Reservoir will not adversely affect the operation of the Cedar Creek Reservoir, now under construction by local interests, nor the proposed Richland and Tehuacana Reservoirs. The spillway rating curve is shown on figure 1, plate 95.
- b. Outlet Works. Four 3- X 6-foot conduits through four of the spillway gate piers would be provided for diversion and conservation releases and for practical draining of the reservoir to elevation 225.0. Each conduit would be controlled by a 3- X 6-foot slide gate at the entrance. Trash racks and stop logs would be provided. The capacity of each conduit would be 610 second-feet at top of conservation pool (elevation 262.5) and 850 second-feet at maximum reservoir level (elevation 297.8). Rating curves for the conduits are shown on figure 2 of plate 95.
- c. Tailwater Rating Curve. The tailwater rating curve at the damsite is shown on figure 3 of plate 95. This rating curve was developed by backwater computations correlated with observed highwater data and measurements at U. S. Geological Survey stream-gaging stations on the Trinity River. The tailwater level at the damsite (prior to closure of the main embankment) for the design discharge of 556,000 second-feet (combined flow spillway and conduit) would be at elevation 250.9.





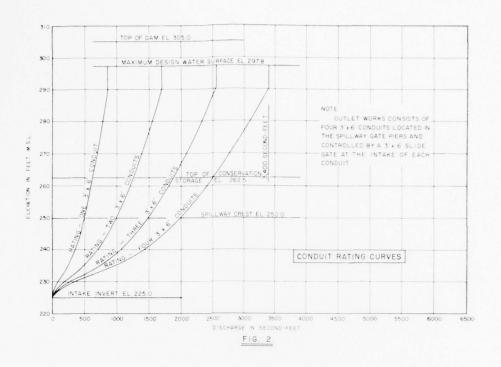


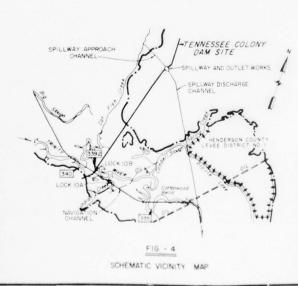




260 250

FIG. - 3





TRINITY RIVER AND TRIBUTARIES, TEXA
TRINITY RIVER
TENNESSEE COLONY RESERVOIR

GENERAL HYDRAULIC DATA

US ARMY ENGINEER DISTRICT, FORT WORTH

US ARMY ENGINEER DISTRICT, FORT WORTH

APPROXIA RECOMMENDED

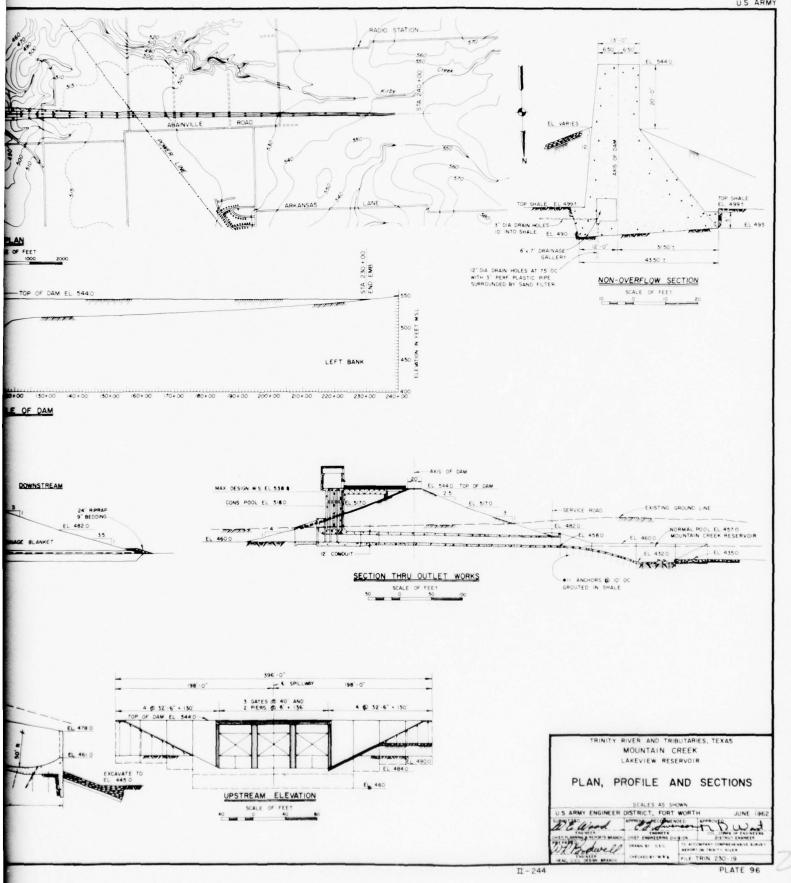
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11-242

PLATE 9

172. LAKEVIEW DAM .-

- a. Spillway. The earthen dam would be located on Mountain Creek at river mile 7.2 with the spillway in a saddle on the right bank. The spillway would consist of an ogee weir with an underdesigned crest at elevation 500.0 controlled by three 40- X 28-foot tainter gates separated by 8-foot piers. Details of the spillway and stilling basin are shown on plate 96. Under conditions of the spillway design discharge (95,100 second-feet through the spillway) the reservoir level would be at elevation 538.8. Energy dissipation would be accomplished by a flip bucket with a 50-foot bucket radius and a 30 degree angle. The top of the bucket lip would be at elevation 461.0. The spillway rating curve is shown on figure 1, plate 97.
- b. Outlet Works. The flood-control outlet works would consist of a 12-foot diameter conduit controlled by two 5-foot 6-inch X 12-foot tractor-type slide gates, with intake inverts at elevation 460.0 and outlet invert at elevation 458.0. The conduit would be used for diversion during construction, for the passage of flood releases, and for the passage of low-flow discharges. The capacity of the flood-control conduit would be 5,000 second-feet at top of conservation pool (elevation 518.0) and 5,900 second-feet at maximum reservoir level (elevation 538.8). The outlet works rating curve is shown on figure 2, plate 97.
- c. Tailwater Rating Curve. The tailwater rating curve at the damsite is shown on figure 3, plate 97. The minimum tailwater level for Lakeview Damsite is based on the normal pool level for Mountain Creek Reservoir, maintained at elevation 457.0. The tailwater rating curve was developed by backwater methods based on the downstream control at the Mountain Creek spillway (river mile 4.1). The tailwater at the damsite (river mile 7.2) for the design discharge of 101,000 second-feet (combined flow spillway and outlet works) would be at elevation 461.6. Lakeview Reservoir was designed to operate in conjunction with the existing Mountain Creek Reservoir and will not adversely affect nor be affected by the existing project.



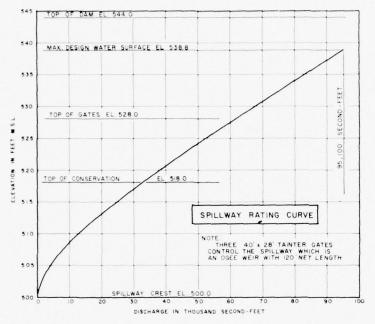


FIG -I

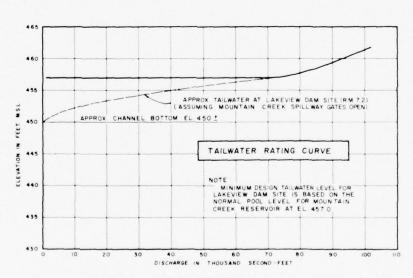


FIG - 3





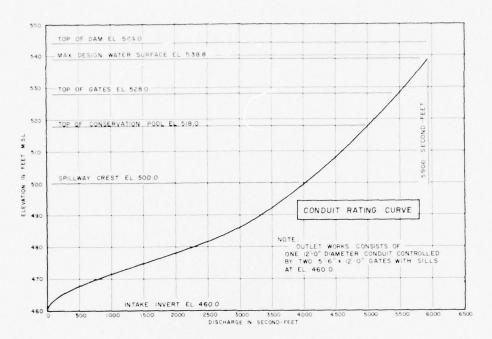
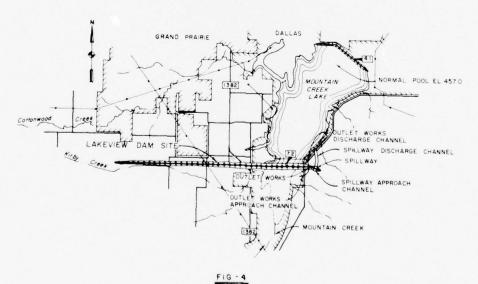


FIG. 2



SCHEMATIC VICINITY MAP

TRINITY RIVER AND TRIBUTARIES, TEXAS
MOUNTAIN CREEK
LAKEVIEW RESERVOIR

GENERAL HYDRAULIC DATA

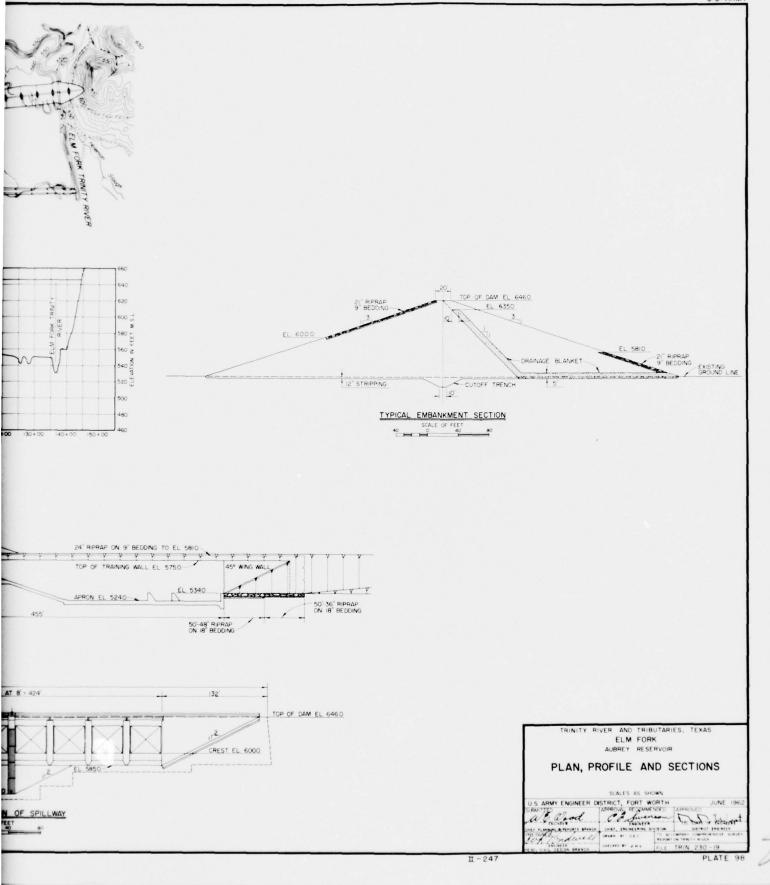
US ARMY ENGINEER DISTRICT, FORT WORTH JUNE, 1963

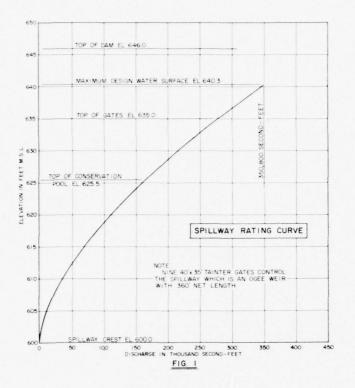
II-245

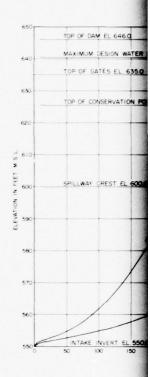
PLATE 97

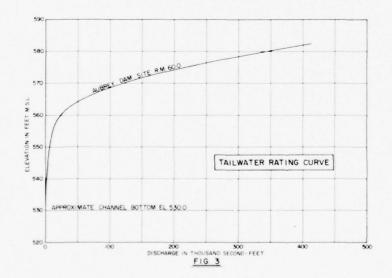
173. AUBREY DAM. -

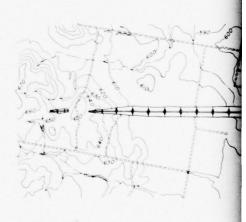
- a. Spillway. The earthen dam would be located on the Elm Fork of the Trinity River at river mile 60.0 with the spillway in a saddle on the right bank. The spillway would consist of an ogee weir with an underdesigned crest at elevation 600.0 controlled by nine 40- X 35-foot tainter gates separated by 8-foot piers. Details of the spillway and stilling basin are shown on plate 98. Under conditions of the spillway design discharge (350,800 second-feet) the reservoir level would be at elevation 640.3. The spillway rating curve is shown on figure 1, plate 99.
- b. Outlet Works. The outlet works would consist of two 36-inch diameter conduits controlled by 36-inch diameter slide gates, with intake inverts at elevation 550.0. The conduits would be used for the passage of low-flow releases and for practical draining of the reservoir to elevation 550.0. The capacity of each conduit would be 280 second-feet at top of conservation pool (elevation 625.5), and 300 second-feet at maximum reservoir level (elevation 640.3). Rating curves for the conduits are shown on figure 2 of plate 99.
- c. Tailwater Rating Curve. The tailwater rating curve at the damsite is shown on figure 3 of plate 99. The tailwater rating was developed by backwater methods correlated with observed highwater data. The tailwater level at the damsite for the design discharge of 350,800 second-feet would be at elevation 580.2.

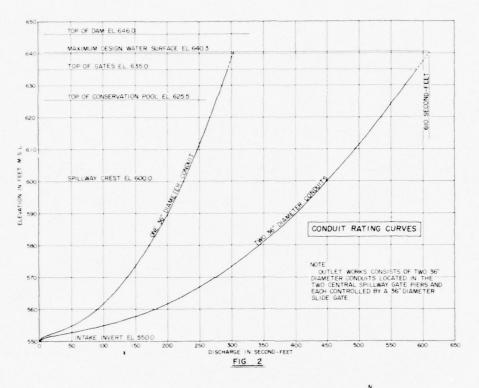


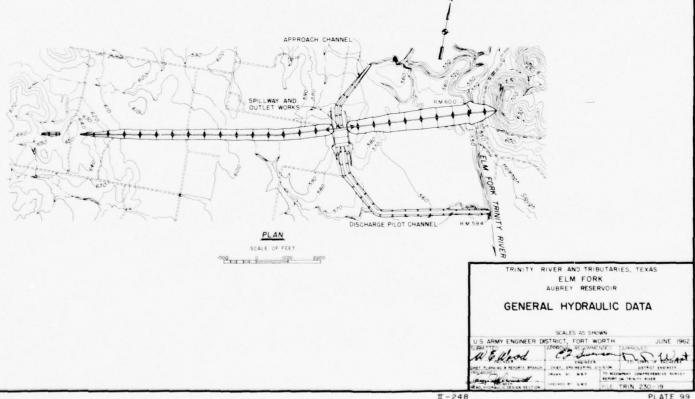






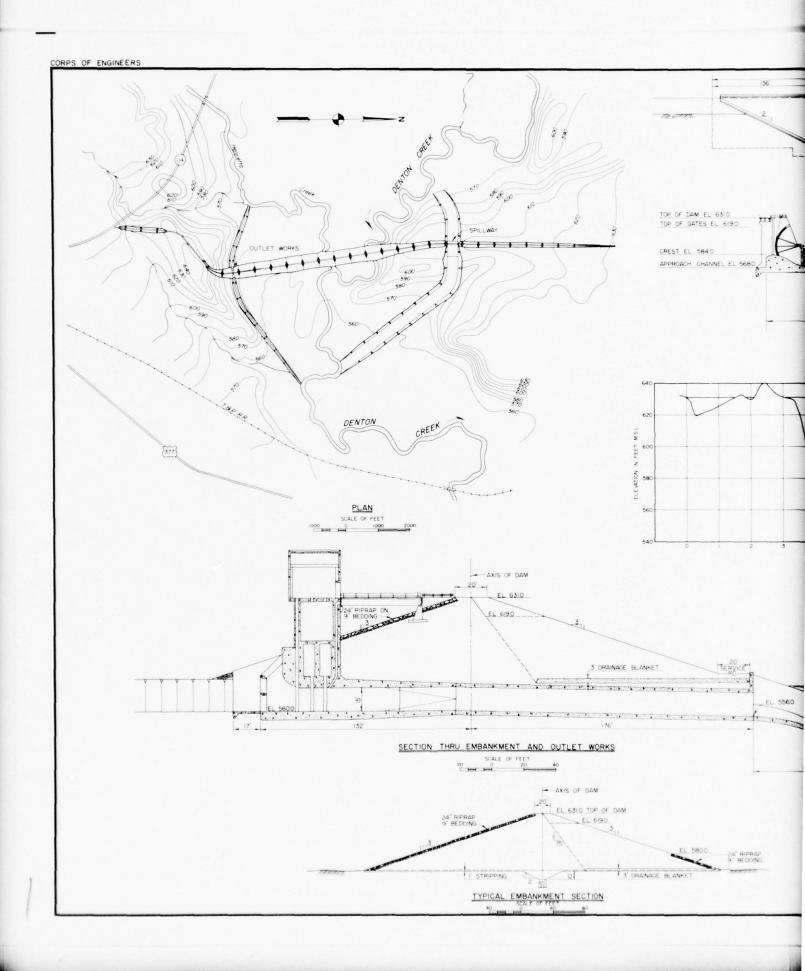


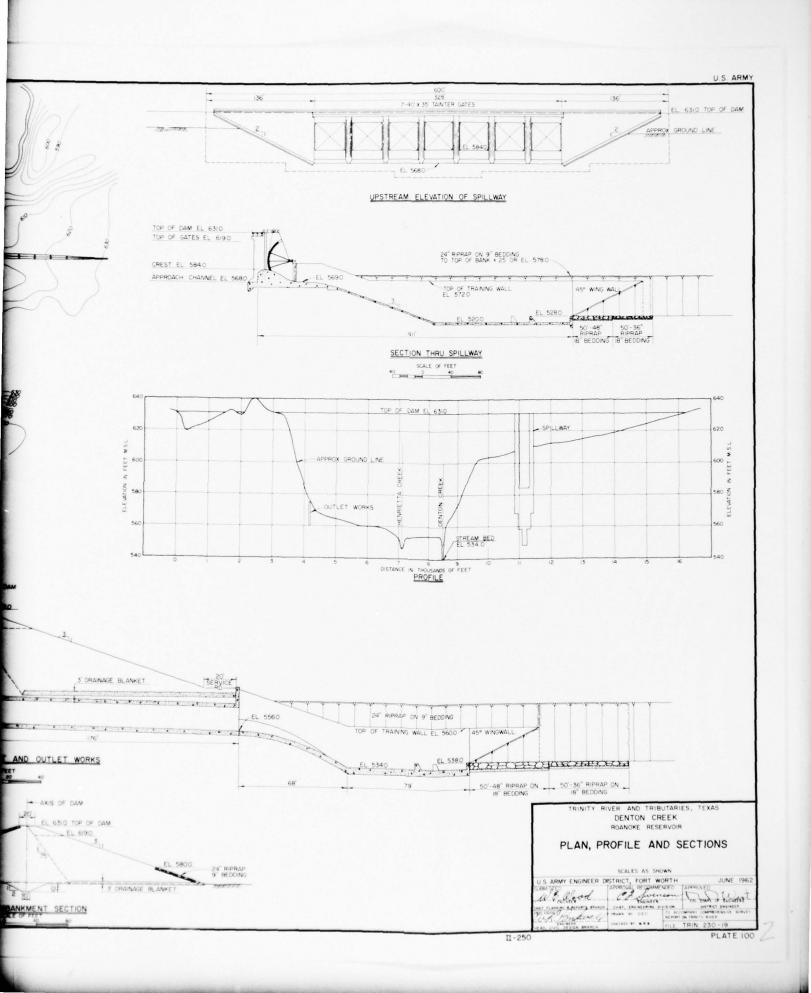


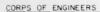


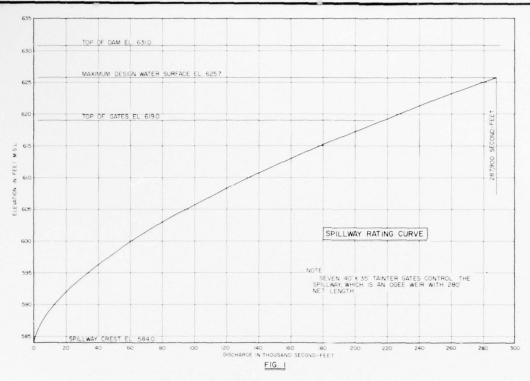
174. ROANOKE DAM .-

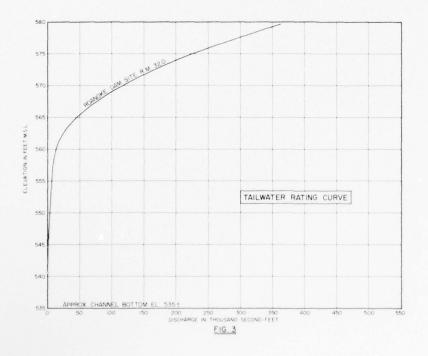
- a. Spillway. The earthen dam would be located on Denton Creek at river mile 32.0 with the spillway in a saddle on the left bank. The spillway would consist of an ogee weir with an underdesigned crest at elevation 584.0 controlled by seven 40- X 35-foot tainter gates separated by 8-foot piers. Details of the spillway and stilling basin are shown on plate 100. Under conditions of the spillway design discharge (287,900 second-feet through the spillway) the reservoir level would be at elevation 625.7. The spillway rating curve is shown on figure 1, plate 101.
- b. Outlet Works. The outlet works would consist of a 15-foot diameter conduit controlled by three 4.5- X 15-foot tractortype slide gates, with intake inverts at elevation 560.0. The conduit would be used for diversion during construction, for the passage of flood releases, and for practical draining of the reservoir to elevation 560.0. The capacity of the conduit would be 9,100 second-feet at maximum reservoir level (elevation 625.7). Rating curve for the conduit is shown on figure 2 of plate 101.
- c. Tailwater rating curve. The tailwater rating curve at the damsite is shown on figure 3 of plate 101. The tailwater rating curve was developed by backwater methods correlated with observed highwater data. The tailwater level at the damsite for the design discharge of 297,000 second-feet would be at elevation 577.5.





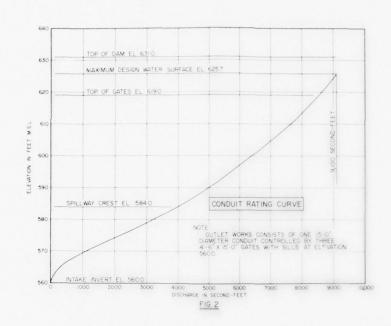


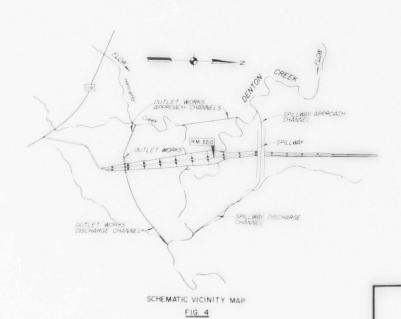












TRINITY RIVER AND TRIBUTARIES, TEXAS
DENTON CREEK
ROANOKE RESERVOIR

GENERAL HYDRAULIC DATA

SCALES AS SHOWN

U.S. ARMY ENGINEER DISTRICT, FORT WORTH

APPROVAL BY JUNE 1962

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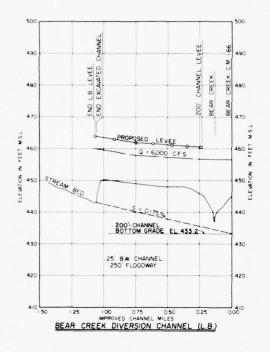
175. TRIBUTARY CHANNEL IMPROVEMENTS - TRINITY RIVER. - The plan of improvement for tributaries of the Trinity River (excluding the East Fork) listed in table 75 and Duck Creek, a tributary of the East Fork, would be designed to provide standard project flood protection. The improvements would consist generally of an improved channel with uniform bottom grades, channel realignment, and levees. The improved channel section would have the channel bottom depressed 1.0 foot at center and would have 1 vertical on 2 horizontal side slopes, except as noted. The levees would be modified or constructed to provide a minimum freeboard of 4 feet above the water surface of the standard project flood. Bridges would have a minimum freeboard of 3 feet. The hydraulic friction losses were based on the Manning formula with coefficients of roughness of 0.035 and 0.070 for channel and overbank, respectively, except as noted. Table 75 shows the approximate Trinity River channel miles and the design conditions at the confluence of each of these tributaries and Duck Creek. The plans of improvement for these tributaries and for Duck Creek are shown on plates 52 through 57, and 102. The proposed channel widths, channel grades, design water surface, levee profiles, and location and sizes of the interior drainage structures are shown on plates 85 and 103 through 108. The details for the plans of improvement of some of the larger tributaries are set forth in the following paragraphs.

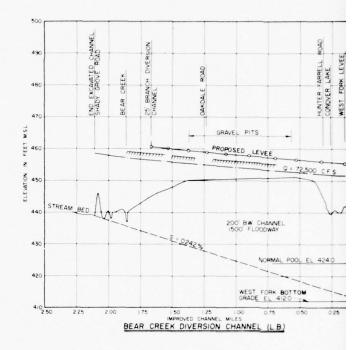
TABLE 75

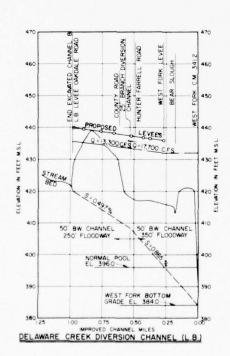
HYDRAULIC DESIGN DATA

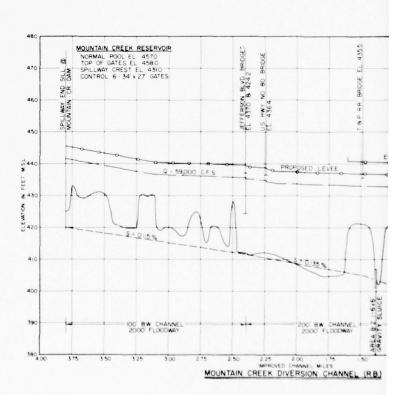
TRINITY RIVER - TRIBUTARY CHANNEL IMPROVEMENTS

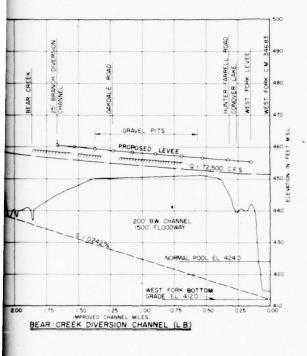
	:		:	Mot	ith	of tribut	ary
Tributary	:	Trinity River channel	:	Design discharge	: :b	Improved channel ottom widt	: water h:surface
	<u>:</u>	mile	:	(cfs)	:	(feet)	:(ft-msl
Five Mile Creek		321.50		63,500		50	396.2
Honey Springs Branch		326.15		4,100		50	404.8
White Rock Creek		326.62		72,100		150	405.7
Elm Fork		338.80		61,000		100	425.5
Mountain Creek		340.89		59,000		300	431.3
Delaware Creek		341.20		17,700		50	432.0
Bear Creek		346.83		72,500		200	451.5
Unnamed Creek		355.13		10,200		50	473.0
Sulphur Branch		356.08		8,100		50	475.6
Walker Branch		359.79		25,800		50	483.5
Unnamed Creek		361.13		1,890		25	489.3
Big Fossil Creek		362.92		52,000		50	497.2
Little Fossil Creek		363.68		17,400		50	500.0
White Lake Outfall		364.71		2,000		25	503.5

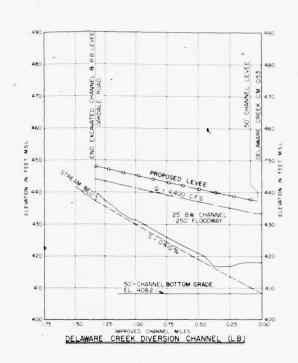


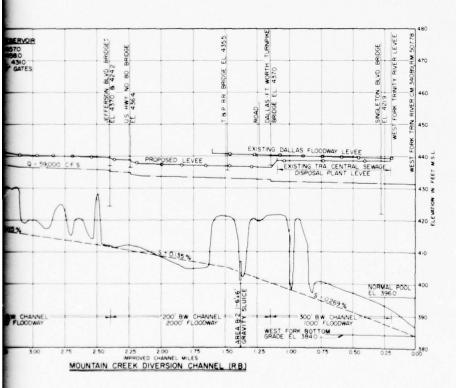












DESIGN WATER SURFACE DESIGN WATER SURFACE LEVEE, RIGHT BANK LEVEE, LEFT BANK CENTERLINE PROFILE BOTTOM GRADE FILL AREA, RIGHT BANK BW BOTTOM WIDTH LB LEFT BANK RB RIGHT BANK

LEGEND

NOTES:

Floodway dimensions shown are minimum requirements measured from centerine of levees, or from centerine of levee to natural bank or fill area.

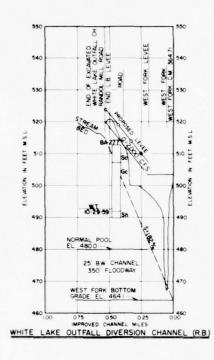
All channel side slopes are I vertical on 2 horizontal. Levee side slopes are I vertical on 2 horizontal.

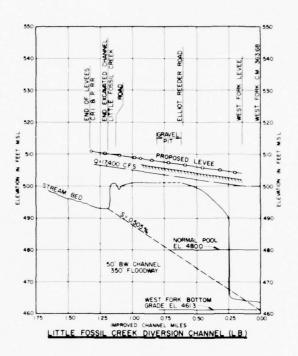
All bridges shown are existing structures Elevations of bridges refer to existing low steel elevations.

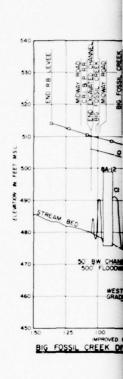
TRINITY RIVER AND TRIBUTARIES, TEXAS WEST FORK TRIBUTARIES
FLOOD CONTROL CHANNELS AND FLOODWAYS

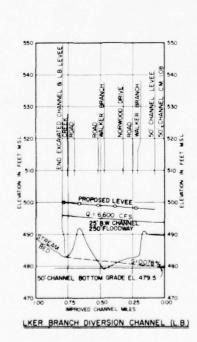
DETAILED PROFILES

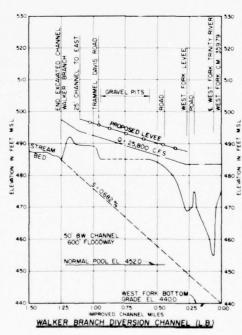
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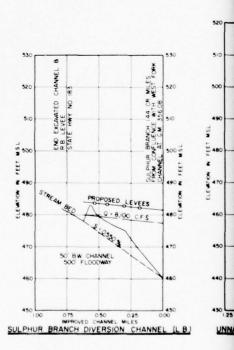




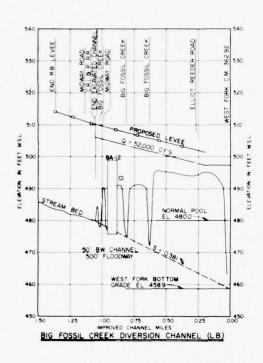


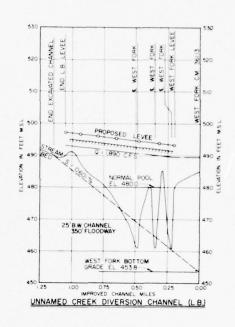


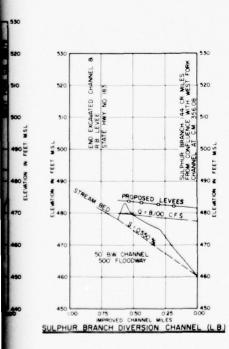


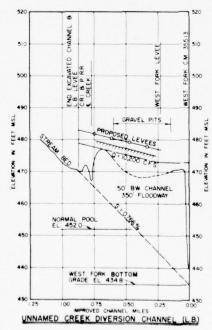












LEGEND

DESIGN WATER SURFACE
LEVEE, RIGHT BANK
LEVEE, LEFT BANK
CENTERLINE PROFILE
BOTTOM GRADE
FILL AREA, RIGHT BANK
BW. BOTTOM WIDTH
LB. LEFT BANK
RB. RIGHT BANK

NOTES:
Floodway dimensions shown are minimum requirements measured from centerline of levees, or from centerline of levee to natural bank or fill requirements of the requirements of the requirements of the requirements of baryantal Levee side slopes are I vertical on 24 horizontal Levee side slopes are I vertical on 24 horizontal All bridges shown are existing structures Elevations of bridges refer to existing low steel elevations. New or modified bridge appending are to provide 3 feet minimum vertical clearance above design water surface, and unobstructed horizontal clearance in dedicated floodway exclusive of bridge piers.

Refer to plate 82 for boring legend

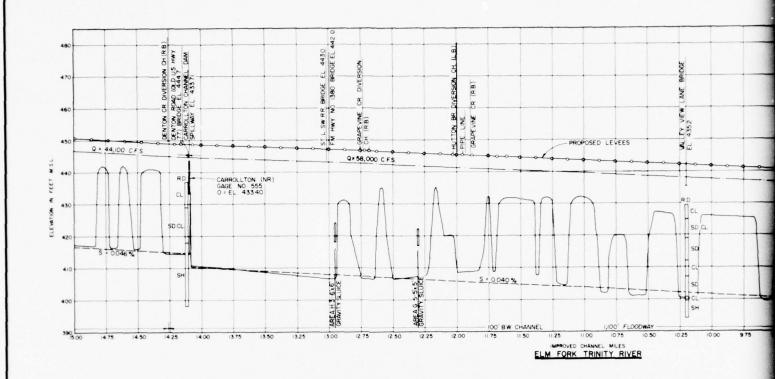
TRINITY RIVER AND TRIBUTARIES, TEXAS WEST FORK TRIBUTARIES FLOOD CONTROL CHANNELS AND FLOODWAYS

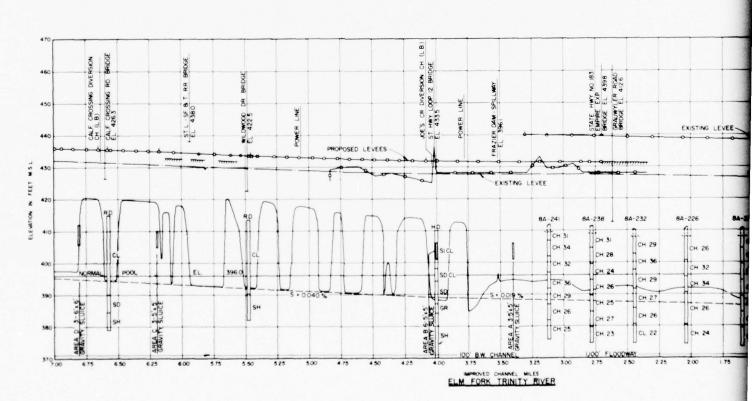
DETAILED PROFILES

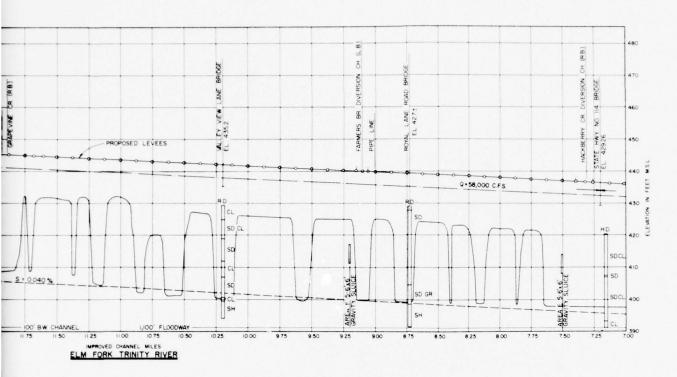
IN 2 SHEETS SCALES AS SHOWN JUNE 1962

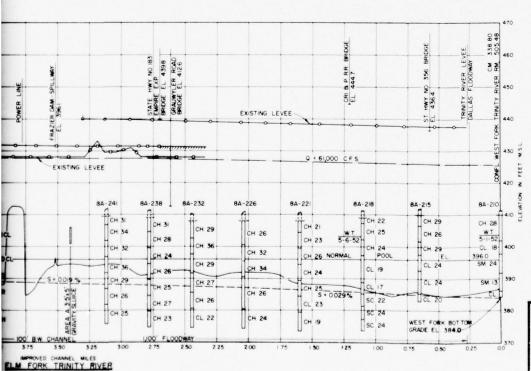
US ARMY ENGINEER DISTRICT, FORT WORTH

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LEGEND

DESIGN WATER SURFACE
LEVEE, RIGHT BANK
LEVEE, LEFT BANK
CENTERLINE PROFILE
BOTTOM GRADE
FILL AREA, RIGHT BANK
BW BOTTOM WIDTH
LB LEFT BANK
RB RIGHT BANK

NOTES

Floodway dimensions shown are minimum requirments measured from centerline of levees, or from centerline of levee to natural bank or fill area All channel side slopes are i vertical on 2 horizontal. Levee side slopes are i vertical on 22 horizontal. Levee side slopes are i vertical on 22 horizontal of bridges shown are existing structures. Electrons of bridges refer to existing low steel elevations. New or modified bridge openings are to provide 3 feet minimum vertical idearance above design veders surface, and unobstructed horizontal clearance in dedicated floodway exclusive of bridge piers.

Refer to plate 82 for baring legend.

Refer to plate 85 for typical channel and levee sections.

TRINITY RIVER AND TRIBUTARIES, TEXAS

ELM FORK AND TRIBUTARIES

FLOOD CONTROL CHANNELS AND FLOODWAYS

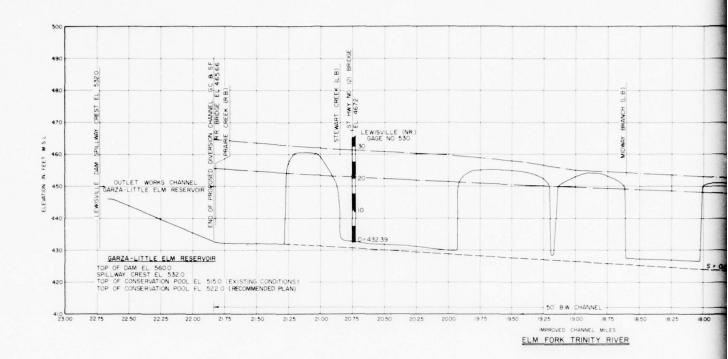
DETAILED PROFILES

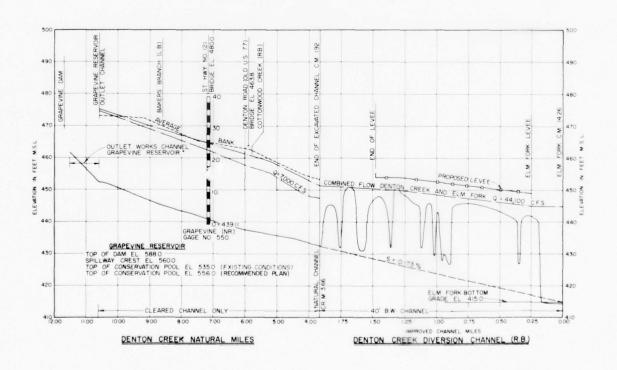
US ARMY ENGINEER DISTRICT, FORT WORTH

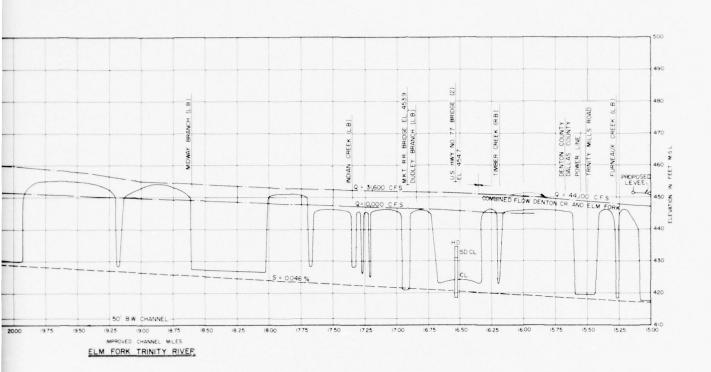
US ARMY ENGINEER DISTRICT, FORT WORTH

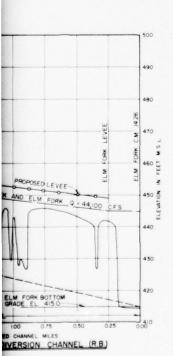
JUNE 1962

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LEGEND

DESIGN WATER SURFACE
LEVEE, RIGHT BANK
LEVEE, LEFT BANK
CENTERLINE PROFILE
BOTTOM GRADE
FILL AREA, RIGHT BANK
BW BOTTOM WIDTH
LB LEFT BANK
RB RIGHT BANK

NOTES: loadway dimensions shown are minimum requirements measured from centerine of levees, or from centerine of levee to natural bank or fill dea.

All channels side slopes are I vertical on 2 horizontal Levee side slopes are I vertical on 2 horizontal Levee side slopes are I vertical on 2 horizontal All bridges sheem one existing structures Elevations of bridges refer to existing low steel elevations. New or modified bridge openings are to provide 3 feel minimum vertical clearance above design water surface, and unobstructed horizontal clearance in dedicated floodway exclusive of bridge piers.

Refer to plate 25 for bring legend.

Refer to plate 25 for bring legend.

TRINITY RIVER AND TRIBUTARIES, TEXAS
ELM FORK AND TRIBUTARIES
FLOOD CONTROL CHANNELS AND FLOODWAYS

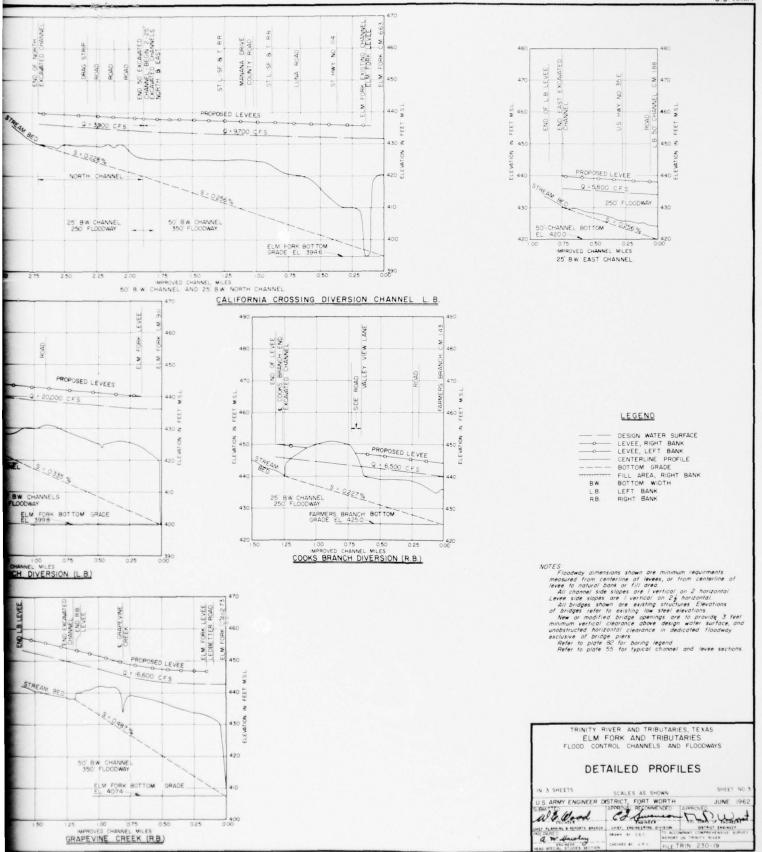
DETAILED PROFILES

U.S. ARMY ENGINEER DISTRICT, FORT WORTH

U.S. ARMY ENGINEER DISTRICT, FORT WORTH

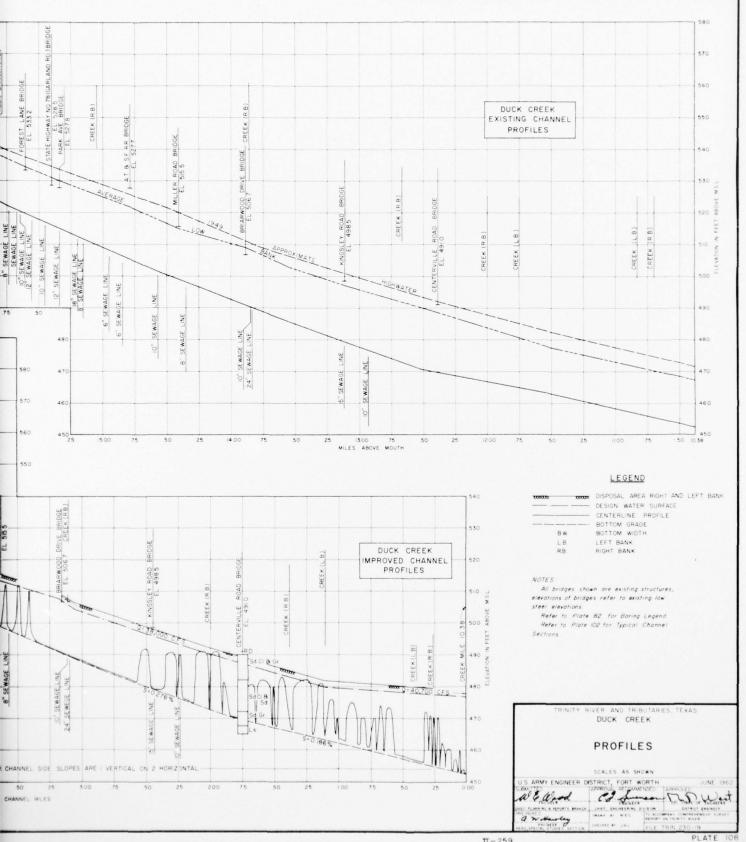
U.S. DISTRICT SOURCE CONTROL OF TRINCETES

CONTROL



II-258

PLATE 107



- 176. EAST FORK IMPROVEMENTS. The proposed plan of improvement for the East Fork would consist of an improved channel which would permit the controlled release of 5,000 second-feet downstream from Forney Pam (river mile 31.8) without blocking the discharge from the interior drainage structures through the existing levees, strengthening the existing levees to provide a 2-foot freeboard above the 50-year frequency flood level, and enlarging the conservation storage for Lavon Reservoir by raising Lavon Dam (river mile 55.9), as set forth in detail in "Review of Reports on Trinity River and Tributaries, Texas, Covering East Fork Watershed." Profiles for the existing conditions are shown on plate 9.
- 177. DUCK CREEK IMPROVEMENTS. The proposed improvement of Duck Creek would extend from Oates Road (river mile 10.38) through the city of Garland, Texas, to Buckingham Road (river mile 17.50). The channel would be enlarged and the bridges would be modified to pass the standard project flood discharge. The improved channel side slopes would be 1 on 2, except in the reach from river mile 14.67 to 15.25 which would have vertical walls. The improved channel would have a bottom width of 150 feet from Oates Road to river mile 15.25, thence 135-foot width to the upstream erd of improvement. Backwater studies were made based on the Manning formula with coefficients of roughness varying from 0.025 to 0.030. Channel velocities would vary from 12 to 17 feet per second under design conditions. The plan of improvement is shown on plate 102. Profiles for the improved and existing conditions are shown on plate 108.
- 178. ELM FORK IMPROVEMENTS. The plan of improvement on the Elm Fork shown on plates 54 and 55 consists of an improved channel from its confluence with the Trinity River (improved channel mile 338.80) to Elm Fork improved channel mile 21.83, the downstream end of the spillway discharge channel for Lewisville Dam. Channel widths would vary from 50 to 100 feet and levees would extend to Elm Fork improved channel mile 15.1 and Denton Creek improved channel mile 1.5. Upstream from the new levees, the improved Elm Fork channel would be designed to carry flows of 10,000 second-feet and the Denton Creek channel, 7,000 second-feet. Table 76 shows the design discharges, channel grades, widths and water surface levels for the improved Elm Fork channel. The tributaries to Elm Fork would be modified by improved channels and levees to complete the levee system of Elm Fork. The design conditions at the confluence of each of these tributaries are shown on table 77. The profiles for the design conditions of Elm Fork and its tributaries are shown on plates 105 through 107.

TABLE 76

HYDRAULIC DESIGN DATA - ELM FORK CHANNEL IMPROVEMENT (Trinity River Channel Mile 338.80, River mile 505.48)

				channel:	Design
		lischarge:Ē		:Bottom:	water
Location	:Channel:		grade	:width :	surface
	: mile :	(1) :(ft-msl)	:(feet):(ft-msl)(2)
Begin Improvement	0.00	61,000	484.00	100	425.5
State Highway No. 356	0.58	61,000	384.89	100	426.0
CRI&P R.R.	1.21	61,000	385.85	100	426.4
Grade Control Change	1.89	61,000	386.90	100	426.8
Grauwyler Road	2.62	61,000	387.63	100	427.3
Empire Expressway	2.70	61,000	387.71	100	427.4
State Highway No. 183	4.01	61,000	389.02	100	427.7
Grade Control Change -	1.01	01,000	309.02	100	.21.1
Joes Creek Diversion Chann	el 4.03	61,000	389.04	100	427.7
Wildwood Drive	5.48	61,000	392.10	100	429.6
St.L-SF&T R.R.	5.93	61,000	393.05	100	430.4
California Crossing Road	6.59	61,000	394.45	100	431.5
California Crossing Road	0.77	01,000	354.47	100	+31.7
Diversion Channel	6.63	61,000	394.53	100	431.6
State Highway No. 114 Brid		61,000	395.74	100	432.6
Above State Highway No. 11		58,000	-	100	~
Hackberry Cr. Diversion Ch		58,000	395.97	100	432.8
Royal Lane Road	8.73	58,000	398.97	100	435.4
Farmers Br. Diversion Ch.	9.11	58,000	399.77	100	436.1
Valley View Lane	10.20	58,000	402.08	100	438.2
Button Branch Diversion Ch		58,000	405.86	100	441.5
Grapevine Cr. Diversion Ch		58,000	407.42	100	442.7
F.M. Highway No. 1380	12.99	58,000	407.97	100	443.1
St.L&SF R.R.	13.02	58,000	408.04	100	443.1
Carrollton Channel Dam	14.09	58,000	410.30	100	444.7
Above Carrollton Dam	-	44,100(3)		50	444.8
Denton RdOld US Hwy 77	14.10	44,100	414.80	50	444.9
Denton Cr. Diversion Ch.	14.26	44,100	415.09	50	445.0
Trinity Mills Road	15.51	44,100	418.01	50	448.5
Discharge Change	16.36	44,100	420.15	50	451.3
Above Denton Cr. Floodplai	-	31,600		50	. , , , ,
U.S. Highway No. 77	16.53	31,600	420.55	50	451.6
MKT R. R.	16.91	31,600	421.47	50	451.8
State Highway No. 121	20.75	31,600	430.72	50	461.4
Grade Control Change	21.29	31,600	432.00	50	462.9
End Proposed Diversion		52,500		, ,	
Channel - GC&SF R.R.	21.83	31,600	432.50	50	464.6
ondanion down nitre		J.,	52.70	, -	

⁽¹⁾ Channel upstream from mile 15.1 designed for 10,000 cfs with no levees recommended.

(3) Combined flow Denton Creek and Elm Fork.

⁽²⁾ Design water surfaces upstream from mile 15.1 reflect overbank flow.

TABLE 77

HYDRAULIC DESIGN DATA TRIBUTARY CHANNEL IMPROVEMENTS ELM FORK

	•	: Mout	h of tributa	ry
Tributary	: Elm Fork : channel : mile		•	/
Joes Creek	4.03	9,700	50	427.7
California Crossing	6.63	9,700	50	431.6
Hackberry Creek	7.31	30,100	50	432.8
Farmers Branch	9.11	20,000	75	436.1
Hutton Branch	11.99	14,500	75	441.5
Grapevine Creek	12.73	16,600	50	442.7
Denton Creek	14.26	44,100	40	445.0

179. MOUNTAIN CREEK IMPROVEMENTS. The proposed plan of improvement for Mountain Creek would consist of improved channel and levees downstream from existing Mountain Creek Dam, river mile 4.1, in addition to construction of Lakeview Dam, river mile 7.2, described in paragraph 174 above. The improved channel would vary from 100 to 300 feet in bottom width and the leveed floodway would pass the standard project flood discharge, 59,000 second-feet, without requiring any modification to the existing Dallas-Fort Worth Turnpike Bridge at improved channel mile 1.14. The plan of improvement is shown on plate 52 and the improved channel profile is shown on plate 103.



WATER RESOURCES STUDY

TRINITY RIVER BASIN, TEXAS

Study of Potential Needs and Value of Water for Municipal, Industrial, and Quality Control Purposes

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service, Region VII
Dallas, Texas

In Cooperation with the

DEPARTMENT OF THE ARMY
U. S. Army Engineer Districts
Fort Worth and Galveston, Texas

SEPTEMBER 1962

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I. INTRODUCTION

Authority

In a letter dated June 8, 1959, the Corps of Engineers, Fort Worth District, requested "HEW views and recommendations on present and prospective municipal and industrial water supply needs in Trinity River Basin, including Houston municipal and industrial complex." The request was subsequently expanded to cover a 100-year future period and to include the needs for storage of water for quality control purposes.

This study has been made in accordance with: (1) the Water Supply Act of 1958 (Public Law 85-500, Title III) and a Memorandum of Agreement between the Department of the Army and the Department of Health, Education, and Welfare, dated November 4, 1958; and (2) the Federal Water Pollution Control Act (Public Law 84-660) as amended by Public Law 87-88.

Purpose and Scope

This report indicates the requirements for municipal, industrial, and water quality control purposes to the year 2070 in the Trinity River basin including the Houston municipal and industrial complex. Estimates are made of the benefits attributable to the storage of water for these purposes in proposed Federal reservoirs.

Acknowledgments

The cooperation of many persons and agencies is gratefully acknowledged. Special appreciation is expressed to the following:

- Bureau of Business Research, University of Texas, Austin, Texas
- Mr. William O. George, Consulting Geologist, Austin, Texas
- Texas Employment Commission, Austin and Dallas, Texas
- 4. Texas Water Commission, Austin, Texas
- Texas State Department of Health, Austin, Texas
- U. S. Army Engineer District--Fort Worth, Fort Worth, Texas

- U. S. Army Engineer District--Galveston, Galveston, Texas
- 8. U. S. Geological Survey, Ground Water Branch, Houston, Texas
- 9. U. S. Study Commission-Texas, Houston, Texas
- 10. Water Departments, officials, and Chambers of Commerce of the following cities:

Athens, Texas Crockett, Texas Dallas, Texas Fort Worth, Texas Galveston, Texas Houston, Texas Palestine, Texas

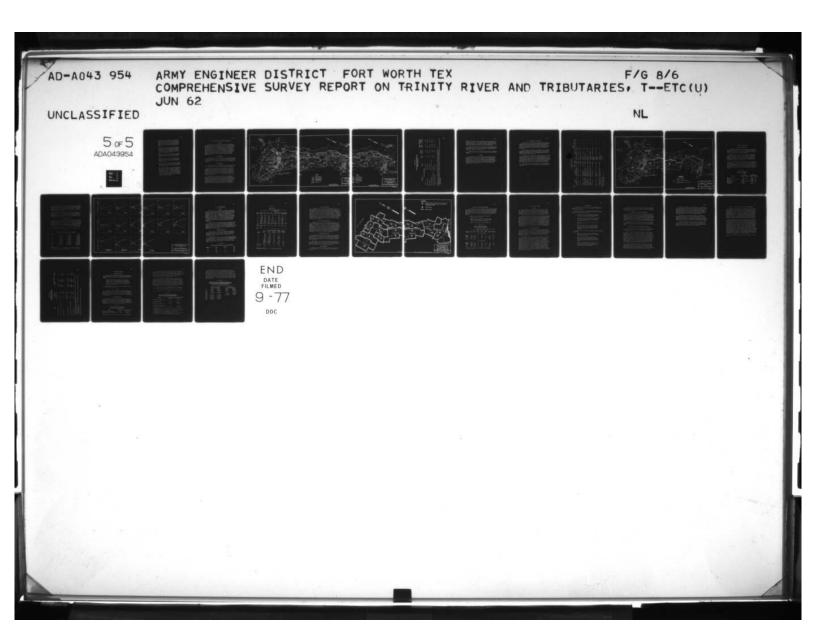
II. SUMMARY AND CONCLUSIONS

Summary

- 1. There are 23 existing, under construction, and authorized reservoirs in the basin with storage capacities in excess of 5,000 acre-feet each. In addition, there are 19 proposed major reservoirs planned within the basin. Of the latter group, only Tennessee Colony, Lakeview, Aubrey, Roanoke, and Wallisville Reservoirs, and the enlargement of Lavon Reservoir are Federal projects.
- 2. All of the projections and estimates contained in this report presuppose: (a) The existence of the Trinity River navigation canal to Fort Worth; and (b) a design drouth similar to the one which occurred in the years 1950-1957.

Conclusions

- 1. Efficient development of all of the water resources of the Trinity River basin is essential to the continued growth of the area. To attain full utilization of these resources for municipal, industrial, agricultural, navigation, and recreation purposes will require abatement of the present pollution in the upper basin as well as control of future pollution throughout the area. Therefore, provision of water to maintain minimum quality conditions in the river must be made a part of the water supply plan until such time as future advances in waste treatment technology can economically provide for removal of residual pollutants before they reach the stream.
- The study area's population is expected to reach 12 million by the year 2020 and 23 million by the year 2070.
- Projected municipal and industrial water needs are 5,100 mgd (million gallons per day) in 2020 and 9,700 mgd in 2070 for the 46-county study area.



- 4. With the water supply plan as herein presented, the potential water resource in the Trinity River basin is sufficient to satisfy all projected water requirements within the basin, including the diversion of the presently agreed amount to the city of Houston until the year 2070.
- 5. To maintain water quality within the Trinity River basin and on the Buffalo Bayou watershed will require releases from storage of about 1,650 mgd in 2020 and 3,600 mgd in 2070 based on 90 percent removal of BOD and 15 percent removal of total dissolved solids.
- Maintenance of water quality within the Trinity River basin beyond the year 2020 is dependent upon the improvement of waste treatment techniques.
- With increased water reuse and minimal use of water for cooling, the projected municipal and industrial study area water needs until 2070 can be satisfied.
- 8. The study area outside the Trinity River basin, with the exception of Houston which will receive 840 mgd, will be served by sources outside the Trinity River basin.
- 9. The estimated benefits of storage by purpose for the six proposed Federal projects in the Trinity River basin are shown in Tables IX-1 and IX-2, pages IX-1 and IX-2. The benefits shown in Table IX-3, page IX-3, for water quality control represent the value of storage for this purpose at the reservoir site plus the cost of transporting the required amount of water in the case of Tennessee Colony Reservoir.

III. WATER RESOURCES OF THE TRINITY RIVER BASIN

General

There has been considerable water resource development in the Trinity River basin in the past. There are 23 existing, under construction, and authorized reservoirs in the basin with storage capacities in excess of 5,000 acre-feet each, and 79 reservoirs having a capacity of less than 5,000 acre-feet. Several agencies have devised plans for the ultimate development of the surface water resource in the basin. The 19 proposed Trinity River basin reservoirs are shown in Figure 1. This report is concerned with six proposed reservoirs in the basin in which there is Federal interest. These are Lakeview, Tennessee Colony, Wallisville, Aubrey, and Roanoke Reservoirs and the enlargement of Lavon Reservoir.

Pertinent Data

Pertinent data on storage capacity, yield, and related facts regarding the proposed projects are presented in Table III-1. The six reservoirs under consideration can provide 592.5 million gallons per day of water for municipal, industrial, and water quality control uses.

Water Quality

The two primary measures of water quality used in this study are total dissolved solids and biochemical oxygen demand (BOD).

The total dissolved solids concentrations of waters within the basin presently vary from a low of 100 mg/l. to a high of 1,000 mg/l. Concentrations in excess of 500 mg/l. are very few and are confined to the lower coastal region. These high concentrations are due to brackish Gulf of Mexico waters which affect the mineral quality of the river as far as 40 miles inland. In general, the mineral quality of the Trinity basin can be described as good to very good.

On the other hand, the organic quality of a large part of waters of the basin is presently very poor. Above Fort Worth and below the San Jacinto County line, the organic quality of basin streams can be classified as good. This is due to light pollution loads entering the basin above Fort Worth and the self-recovery of the stream from the high loads imposed by the Fort Worth and Dallas complex by the time the river reaches the San Jacinto County line. Below the confluence of Marine Creek with the West





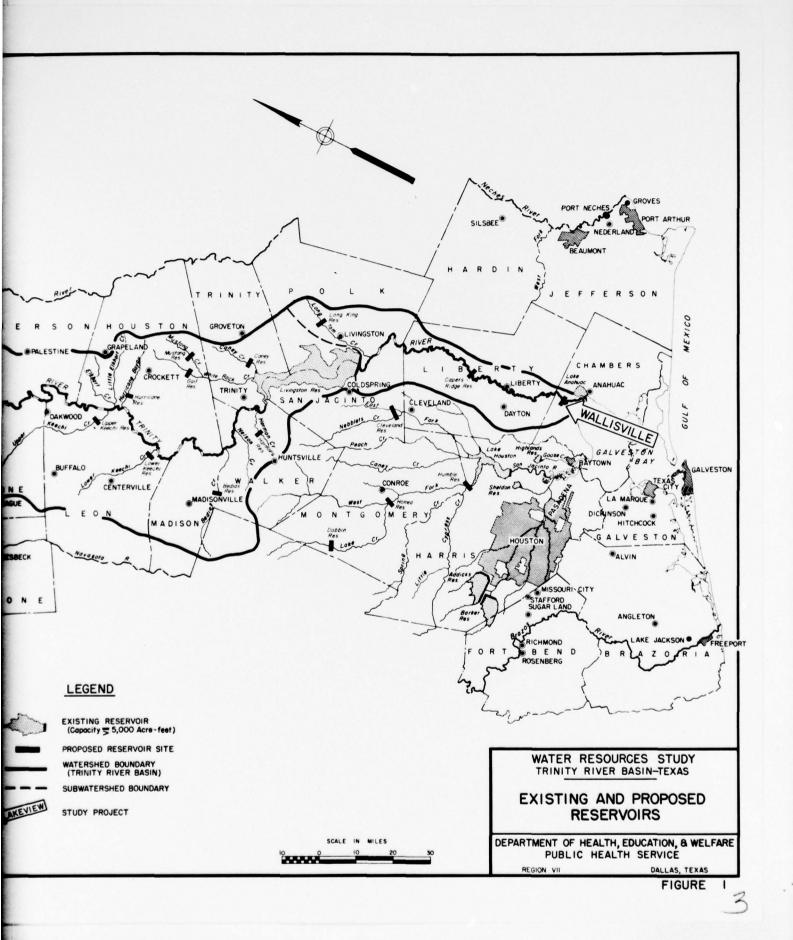


Table III-1

Pertinent Data--Proposed Reservoirs Trinity River Basin

		River	Drainage Area	Water Sug 2020 Yield	Water Supply Pool 2020 Storage Yield (Millions
Reservoir	Stream	Mi le	(Sq. Mi.)	(pgm)	of Gals.)
Corps of Engineers	ineers				
Lakeview	Mountain Creek	7.2	272	28.4 a/	99,841
Tennessee Colony	Trinity River	339.6	12,687	290.8	336,441
Wallisville	Trinity River	3.9	17,760	146.0	13,621
Lavon (Enlargement)	East Fork Trinity River	55.9	777	42.7 5/	85,470
Garza-Little Elm-Aubrey System	Elm Creek	0.09	682	65.3 5/	196,749
Grapevine-Roanoke System	Denton Creek	31.4	909	23.9 5/	0

 $\frac{a}{b}'$ Yield does not include 2.0 mgd utilized by the existing Mountain Creek Reservoir. $\frac{b}{b}'$ Storage and yield shown are increases resulting from reservoir enlargement. $\frac{c}{b}'$ Yields shown are increases in system yields based on storage exchange with Grapevine and Garza-Little Elm Reservoirs. Fork in Fort Worth and downstream to Rosser in Kaufman County, the conditions in the river are generally anaerobic and associated offensive odors persist. Downstream from Rosser, sufficient tributary dilution and reaeration occur, almost overcoming the effects of the organic pollution, upon reaching the San Jacinto County line.

With the exception of the watershed of the proposed Tennessee Colony Reservoir, the waters in the watersheds of the proposed reservoirs are not presently subjected to extensive contamination from communities, industries, or other sources.

The waters at all six proposed reservoir sites are considered acceptable as raw water supply for general municipal and industrial purposes.

Runoff

Runoff within the area is characterized by large variations annually as well as seasonally. Within the Trinity River basin, periods of zero flow have been experienced on all tributaries of the river with the exception of the West Fork between Fort Worth and Dallas where upstream sewage releases account for the base flow of the stream during dry periods. The estimated average annual natural runoff of the entire Trinity River basin for the period 1941-1956 was 5,770,200 acre-feet.

IV. DESCRIPTION OF STUDY AREA

Those counties which lie within the Trinity River basin and those adjoining counties which could reasonably be served by waters from the basin, or are an economic part of the potential water service area, were included in the study area. This area, as shown in Figure 2, comprises 46 counties representing approximately 15 percent of the land area of the State of Texas and 43 percent of its population.

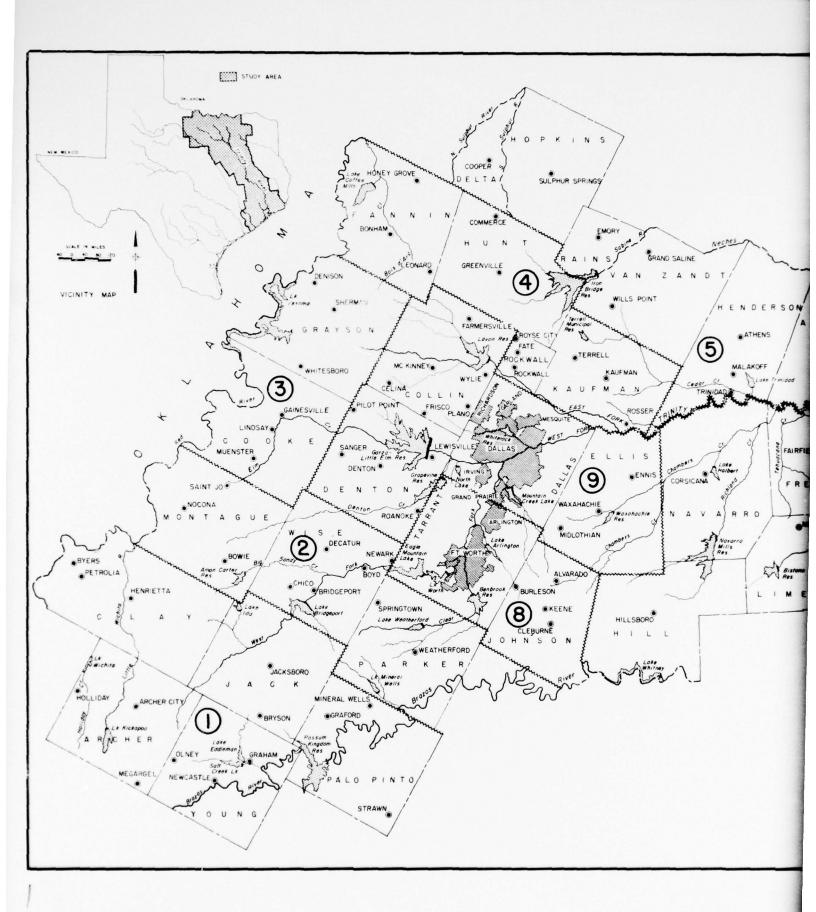
The study area was divided into 10 subareas for the purpose of providing suitable size base areas for study, at the same time maintaining a reasonable degree of homogeneity of economic, water resource, and geographic factors. The characteristics of the several subareas are shown in Table IV-1.

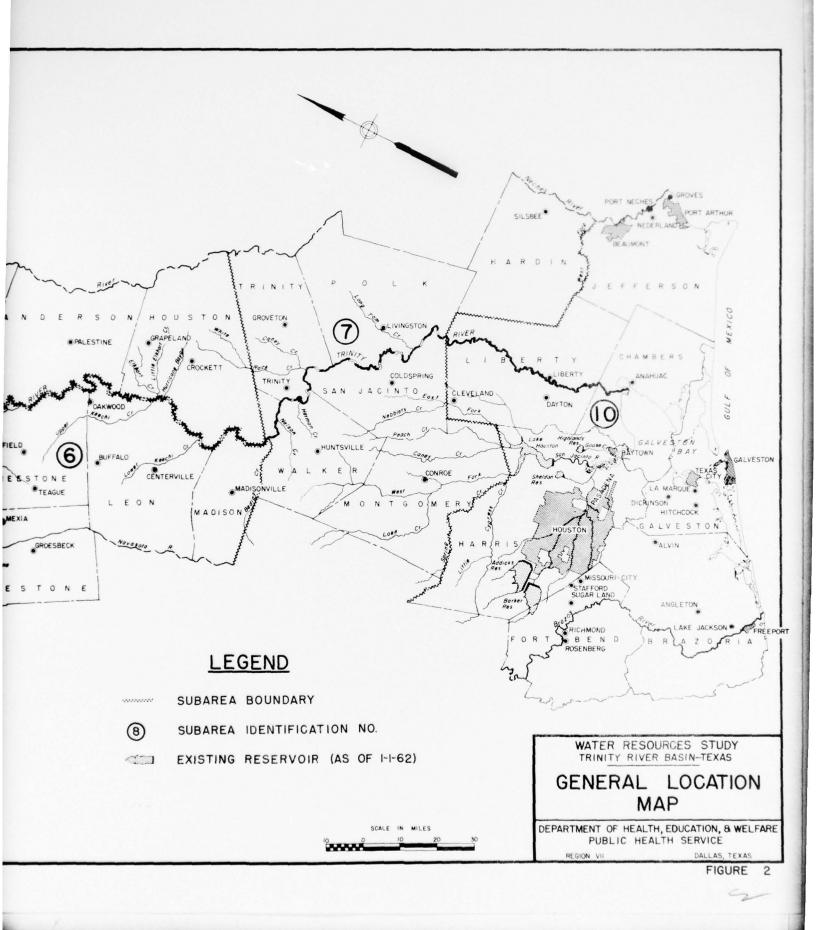
The climate of the study area is extremely diverse. It varies from dry, subhumid in the northwest to humid along the coast of the Gulf of Mexico. Heavy rainstorms are common throughout the area and occasional tropical storms enter the area from the gulf. Average winter and summer temperatures in the northwestern half of the area vary from $42^{\rm O}F$ to $85^{\rm O}F$, and in the southeastern half from $54^{\rm O}F$ to $83^{\rm O}F$. Mean annual rainfall varies from 27 inches at the extreme northwestern edge of the area to 51 inches along the gulf coast.

The growing season is about 232 days in the northeastern portion of the area and, in the southeastern portion, averages about 277 days.

								Mean		
Sub- area No.	Counties	Principal Cities	1960 Popu- lation	Population Class	Economy	Topography	Alti- tude (feet)	Temper- ature (OF)	Growing Season (days)	Avg. Rainfall (inches)
-	Archer, Clay, Jack, Palo Pinto, Young	Holliday, Henrietta, Jacks- boro, Mineral Wells, Graham	59,649	Non-Metro- politan	Farm - Live- Rolling stock and oil to hilly	Rolling plains to hilly	800- 1,450	79	220	27.6
7	Montague, Parker, Wise	Bowie, Weatherford, Deca- tur	54,785	Non-Metro- politan	Farm - Live- stock	Rolling plains to hilly	700-	63	228	30.6
en	Cooke, Grayson	Gainesville, Sherman	95,603	Non-Metro- politan	Industrial, Agricultural, Oil	Rolling plains	500-	99	235	36.7
4	Fannin, Hunt, Kaufman, Rockwall	Bonham, Greenville, Terrell, Rockwall	880,66	Non-Metro- politan	Agricultural, Industrial	Agricultural, Rolling plains Industrial	300-	79	233	40.1
'n	Anderson, Delta, Henderson, Hopkins, Houston, Rains, Van Zandt	Palestine, Cooper, Athens, Sulphur Springs, Crockett, Emory, Canton	115,862	Non-Metro- politan	Agricultural, Rolling Forest, Indus-hilly trial, 0il	Rolling to -hilly	200-	99	243	40.2
9	Freestone, Hill, Leon, Limestone, Madison, Navarro	Fairfield, Hillsboro, Centerville, Mexia, Madisonville, 107,711 Corsicana	107,711	Non-Metro- politan	Agricultural, Livestock, Industrial	Agricultural, Level to rolling Livestock, Industrial	g 200- 900	99	243	38.0
7	Hardin, Montgomery, Polk, San Jacinto, Trinity, Walker	Kountze, Conroe, Livingston,100,496 Coldspring, Groveton, Hunts- ville	100,496	Non-Metro- politan	Agricultural, Livestock, Forest, Oil	Agricultural, Coastal plain Livestock, to rolling Forest, 0il	30-	67	261	47.5
80 81	a/ Johnson, Tarrant	Cleburne, Fort Worth	573,215	Metro- politan	Industrial, Commercial, Some Agri- cultural	Rolling prairie	500-	9	238	33.3
/9 6	½/ Collin, Dallas, Denton, Ellis	McKinney, Dallas, Denton, 1,083,601 Waxahachie	083,601	Metro- politan	Industrial- Commercial, Some Agri- cultural	Rolling prairie	300-	99	238	35.7
10 2/	L Brazoria, Chambers, Fort Bend, Galveston, Harris, Jefferson, Liberty	Freeport, Anahuac, Rosen- 1,787,886 berg, Galveston, Houston, Beaumont, Liberty	787,886	Metro- politan	Industrial Commercial, Oil, Chemical, Forest, Agri-	Coastal Plains	300	89	288	46.3
ले के जे	a/ Comprises the Fort Worth SMSA. b/ Comprises the Dallas SMSA. c/ Includes the Houston, Beaumont,	A. nt, Port Arthur, and			cultural, Live- stock	- 9				IV-2

C/ Includes the Houston, Beaumont, Port Arthur, and Galveston-Texas City SMSA's.





V. ECONOMICS AND POPULATION

Economic Projections

Agricultural production of the study area is expected to increase 140 percent by the year 2020. Four percent of the labor force, or 70,112 workers, were engaged in agriculture in 1960. By 2020, 1 percent of the labor force, or 55,100 workers, will be sufficient to achieve the expected production.

Mining is very important to the economy of the study area and accounts for about 21 percent of its income. In 1960 almost 3 percent of the area's labor force was employed in mining compared to a national average of slightly more than 1 percent. Employment in mining is expected to increase from 45,909 workers in 1960 to 76,700 workers in 2020. This will represent about 2 percent of the labor force in 2020.

A part of the projected national increase in the demand for timber and forest products will be satisfied by these resources of the study area. The present production rate is only 52 percent of the net annual growth and can be expected to improve with good forestry management practices. Employment in forestry can, therefore, be expected to increase from 1,382 in 1960 to 27,000 by the year 2020. A summary of present and future employment is shown in Table V-1.

Table V-1
Study Area Employment
Present and Projected

	196	0	202	:0
	Labor	Force	Labor	Force
Industry	Number	Percent	Number	Percent
Agriculture	70,112	4.3	55,100	1.2
Forestry and Forest Products	1,382	0.1	27,000	0.6
Mining	45,909	2.8	76,700	1.6
Manufacturing	323,454	19.9	1,004,800	21.4
Service Industries	1,114,302	68.4	3,347,400	71.2
Unemployed	74,139			
Labor Force	1,629,298		4,699,100	

The manufacturing industries are expected to form an important part of the future economic base of the study area. Employment in these categories has increased 157 percent in the two decades since 1940. In 1960, 323,454 workers, or 20 percent of the labor force, were engaged in manufacturing. By 2020, about 21 percent, or 1,004,800, will be so employed.

The service industries, which include sales, insurance, finance, personal services, and transportation, employed 68 percent of the labor force, or 1,114,302 workers, in 1960. Based on past national trends modified by relative growth and income in the area, comparable employment in 2020 will be about 3,347,000 workers, or 71 percent of the labor force.

Population Projections

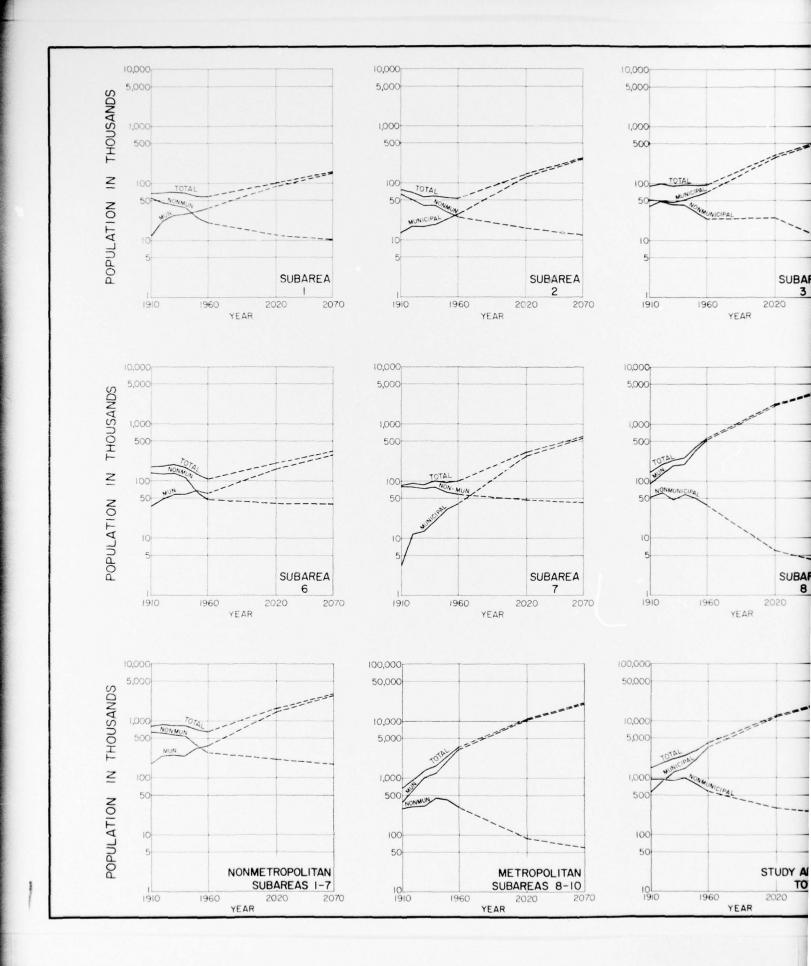
The rate of population growth in the three metropolitan subareas has been about 3.5 percent per year compared to the national average for metropolitan centers of about 2.25 percent. This trend of higher growth rates in the study area can be expected to continue as indicated by its economic potential. The metropolitan subareas of Dallas, Fort Worth, and Houston are projected to increase from 3,444,702 in 1960 to 10,722,000 by 2020 and to 20,101,000 by 2070.

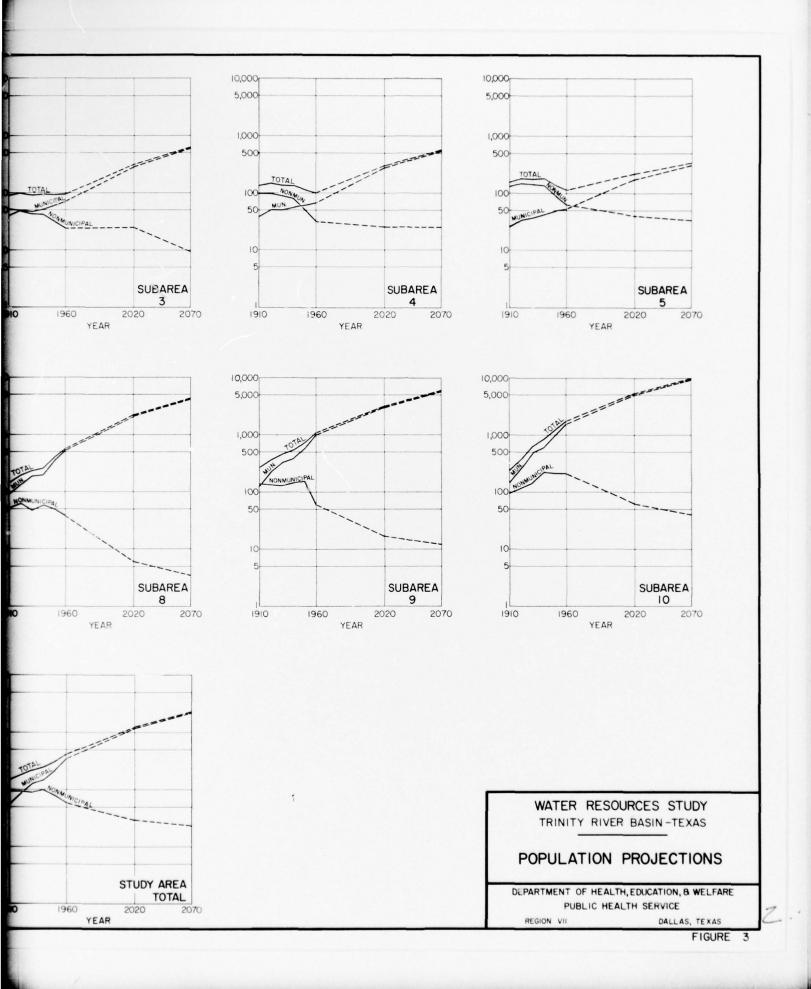
A summary of the population projections by subareas is presented in Table V-2 and Figure 3.*

Table V-2
Population Base and Projections by Subareas

1960	2020	2070
59,649	101,000	160,000
54,785	148,000	282,000
95,603	314,000	628,000
99,088	304,000	575,000
115,862	220,000	350,000
107,711	204,000	325,000
100,496	328,000	614,000
573,215	2,265,000	4,247,000
1,083,601	3,199,000	6,001,000
1,787,886	5,258,000	9,853,000
4,077,896	12,341,000	23,035,000
	59,649 54,785 95,603 99,088 115,862 107,711 100,496 573,215 1,083,601 1,787,886	59,649 101,000 54,785 148,000 95,603 314,000 99,088 304,000 115,862 220,000 107,711 204,000 100,496 328,000 573,215 2,265,000 1,083,601 3,199,000 1,787,886 5,258,000

^{*}Municipal is defined here as including the population of all places of 1,000 or more persons, and nonmunicipal is the classification used for the remainder of the population.





VI. WATER REQUIREMENTS

General

Under the provisions of Title III, Public Law 85-500, the inclusion of storage to meet present or anticipated future demand or need for municipal and industrial water is authorized in any reservoir project surveyed, planned, or constructed by the Corps of Engineers, U. S. Army. A Memorandum of Agreement dated November 4, 1958, between the Department of the Army and the Department of Health, Education, and Welfare states that the Public Health Service will submit to the Corps of Engineers a report of its views and recommendations on present and prospective needs for municipal and industrial water supply and the desirability of meeting those needs from the project or projects under consideration.

The probable future water requirements of the study area in the year 2020 are based on detailed economic and population projections, coupled with analyses of unit water requirements. The overall unit water use determined for the projected population in 2020 is assumed to remain constant for the period from 2020 to 2070. Therefore, determination of the 2070 water requirements involves population as the only variable.

Municipal Water Use

Municipal water is defined here as municipally supplied water for all purposes excluding that supplied to industrial establishments. Included in the resulting per capita quantities are losses in the distribution system, treatment plants, and terminal reservoirs.

Future municipal water needs are calculated by multiplying the estimated 2020 per capita use by the projected municipal population for the area. The expected variation in gallons per capita day use with climate in the study area is shown in Table VI-1. Total estimated municipal requirements are summarized in Table VI-2.

Table VI-1

Per Capita Municipal Water Use for the Year 2020

Subarea	gpcd	Subarea	gpcd
1	180	6	165
2	175	7	155
3	170	8	175
4	160	9	175
5	160	10	155

Table VI-2
Subarea Needs

			2020	Water N	Needs in	MGD		
					Thermal			
					Power	Non		
Sub-	Total	Total*		Indus-	Genera-	munic =	Irri-	Navi-
area	Water	M. & I.	<u>ipal</u>	trial	tion	ipal	gation	gation
1	20.9	18.6	15.7	2.9		2.3		
2	30.6	27.5	22.7	4.8		3.0	0.1	
3	60.3	55.9		6.7		4.4		
4	80.0	48.5		4.3		4.6	26.9	
5	196.2	140.2	28.6	67.9		7.2	48.8	
6	131.6	77.5	26.8	50.7		7.2	46.9	
7	302.5	268.2	43.6	224.6		8.6	25.7	
8	582.1	580.8	394.9	74.5	111.4	1.1	0.2	
9	782.7	774.2	554.9	67.5		3.1	5.4	
10		3,107.5		2,047.7		11.5	275.1	57.0
Study								
Area	5,638.0	5,098.9	1,974.5	2,551.6	572.8	53.0	429.1	57.0
% of								
Total	100.0	90.5	35.0	45.3	10.2	0.9	7.6	1.0
			20	70 Water	Needs i	n MGD		
		Total	Total	No.	on-	Irriga-	Navi	ga-
Subar	rea	Water	M. & 7	. mun:	icipal	tion	tio	n
1		33.8	31	9	1.9			
2		58.8	56		2.2	0.1		
3		121.3	119		1.7			
4		127.1	95		4.6	26.9		
5		293.4	238		5.1	48.8		
6		191.1	137		7.2	46.9		
7		582.7	549		7.7	25.7		
8		1,091.8	1,091		0.6	0.2		
9		1,429.4			2.2	5.4		
10		6,249.3			7.9	275.1	57.	0_
Study	Area	10,178.7	9,650	.5 42	2.1	429.1	57.	0
% of 1	Total	100.0	94	.8 (0.4	4.2	0.	6

^{*}Including consumptive use for thermal power generation.

Industrial Water Use

The definition of industrial water used here refers to all water regardless of source used by the manufacturing industries (Standard Industrial Classification categories 13, 14, and 20 through 39). The total industrial requirements are determined by combining the projected number of employees with the projected unit employee water use for each of the several industrial categories. Industrial water use is shown in Table VI-2. Regional differences in industrial practice have been accounted for in the base data which were obtained from an industrial survey of the study area. Adjustments have been made for anticipated recirculation and reuse practices. Figure 4 illustrates the variation which is expected in unit water use for a composite of all industries.

Power Generation Water Use

Consumptive water use for thermal power generation is a part of the industrial requirements but is determined separately since water for this purpose is a function of population rather than employment. Information on future water use was gathered from power companies in the area and combined with data developed by the Federal Power Commission and the Edison Electric Institute for the Senate Select Committee on National Water Resources. The general locations of future power generating installations were determined and the projected needs apportioned throughout the study area according to the service areas for the several generating plants. The water requirements for this purpose are shown in Table VI-2.

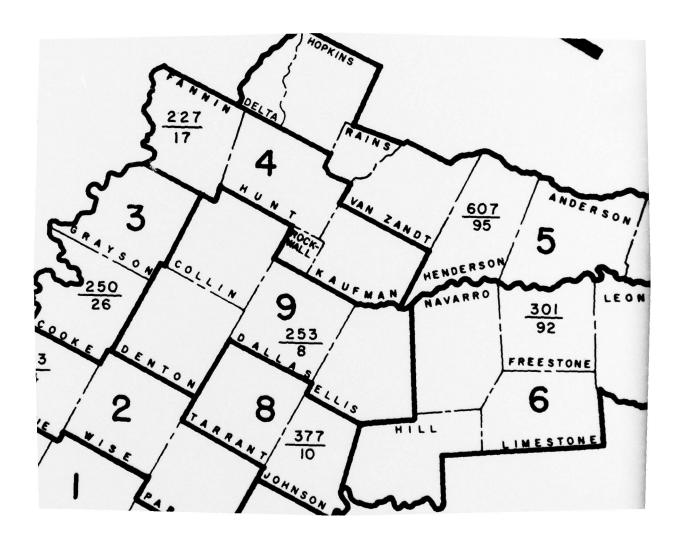
Nonmunicipal Water Use

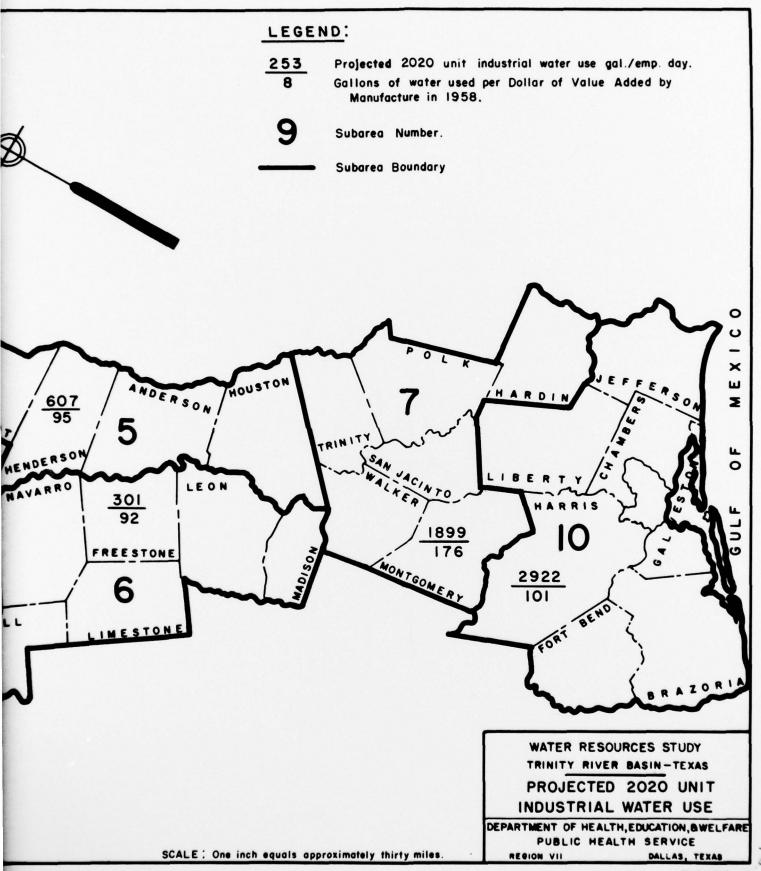
A small segment of the total water needs that is sometimes overlooked is that of nonmunicipal water supply for purposes other than irrigation. In an area where the terminal year requirement for all of the water available is anticipated, however, an estimate of this use becomes necessary so as not to understate the total water requirements.

For purposes of this study, the nonmunicipal water requirements are assumed to consist of domestic water for nonmunicipal population and water for the maintenance of livestock. The requirements for nonmunicipal water are shown in Table VI-2.

Other Water Uses

Projected irrigation and navigation uses were furnished by the Corps of Engineers. These estimates are also included in Table VI-2.





Projected Basin Water Requirements

For purposes of comparison with previous and concurrent studies and to avoid duplication of water demands in adjoining river basins, projections of water demand for the area totally within the boundaries of the Trinity River basin were also estimated and are shown in Table VI-3. These were calculated from the subarea projections shown in Table VI-2. In this case, the basin is divided into three parts as follows:

- Upper: All of the watershed area upstream of Tennessee Colony Reservoir.
- 2. Middle: The watershed area downstream of the upper basin and upstream of the north boundary lines of Polk and San Jacinto Counties.
- 3. Lower: The remainder of the watershed area.

Table VI-3

Projected Water Requirements for the Trinity River Basin

	Water Requirements in MGD						
Subbasin	Total	Total M&I*	Non- munic- ipal	Irriga- tion	Naviga- tion	Export	Quality
			For t	he Year 2	020		
Upper	1,677	1,513	15	69	0	0	80
Middle	295	227	3	65	0	0	0
Lower	1,461	<u>340</u>	_2	222	<u>57</u>	840	_0
Total	3,433	2,080	20	356	57	840	80
			For t	he Year 2	070		
Upper Middle Lower	2,877 504 1,806	2,797 435 686	11 4	69 65	0 0	0 0	0
Total	5,187	3,918	<u>1</u> 16	222 356	<u>57</u> 57	840 840	<u>_0</u>
Iotal	5,167	3,910	10	336	3/	040	U

^{*}Includes consumptive use for thermal power generation.

VII. WATER QUALITY CONTROL

General

Under the provisions of the Federal Water Pollution Control Act, Public Law 84-660 as amended, consideration must be given to the inclusion, in any reservoir being planned by a Federal agency, of storage for regulation of streamflow to control water quality. Storage and release of this water is not to be provided as a substitute for adequate treatment or control of wastes at their sources.

When treatment methods improve, the need for addition of water to maintain quality will diminish and may someday entirely disappear. Until such time, however, it is essential that recognition be given to the need for flows which must prevail in receiving streams if their water quality is to be maintained at acceptable levels. Therefore, estimates of the water required to maintain quality in the waters of the Trinity River basin and in the Buffalo Bayou watershed have been made since these demands are an inseparable part of the water supply plan for the study area. For the remainder of the area outside the Trinity River basin, studies of wastes were not made since their disposal is not expected to affect the interbasin transfer of water.

Quality Parameters

The determination of water quality takes into consideration the wastes which will result from the economic development of an area and the effects of these wastes on stream regimen. At any point in a stream, the water quality will be the result of mixing various qualities and quantities of water which make up the total flow modified by forces such as reaeration and evaporation which tend to change its character.

A comprehensive study of water quality requires the analysis of a large number of individual contaminants which occur in most streams. For long-term planning, however, it is not considered necessary to make detailed studies of this nature. Estimates of pollution are based on water use as a logical outgrowth of present conditions and technology. To assign values to a multiplicity of waste constituents would create an apocryphal condition without any degree of probability. Therefore, quality analysis is based on broad parameters which are currently available for evaluation of future stream conditions. Total dissolved solids projections are employed to characterize the effects of stable pollutants (those constituents which are not utilized or reduced by stream environment). Dissolved oxygen content is applied as a measure of unstable pollutants (those constituents which decay and act on, or are acted on by the stream environment).

Stream Loading

An estimate of waste loads likely to be discharged to the stream in the future is the first step necessary in forecasting water quality conditions.

The expected amounts of return flow and characteristics of the wastes were estimated and the following assumptions regarding quality control requirements were made.

- 1. Sufficient treatment will be provided to remove 90 percent of the biochemical oxygen demand and 15 percent of the total dissolved solids.
- Evaporation and seepage from streams are reflected in streamflow records requiring no adjustment.
 Adjustments for evaporation in reservoirs were necessary, however.
- Uniform mixing of wastes and receiving waters will occur.
- 4. Water for quality control is required when the dissolved oxygen content of the mixed water in the stream is below 4.0 milligrams per liter (mg/1.) or the total dissolved solids exceed 1,000 mg/1.

Analysis of the basin based on the above assumptions indicated the following:

- 1. The waters of the basin will not be degraded below acceptable limits by the stable pollutants (total dissolved solids).
- Organic pollution in the reach between Fort Worth and the Tennessee Colony Reservoir site exceeds the assimilative capacity of the stream at present and will continue to do so in the future.
- 3. The waters available for quality control in the basin upstream of the points of need are not adequate to raise the dissolved oxygen level of the stream to acceptable standards.

Further studies, however, indicated that a plan for maintaining the water quality of the basin could be developed through efficient use of available dilution water and allowances for improved waste treatment technology.

Availability of Quality Control Water

Since this report recognizes prior commitments, agreements, and permits of local interests, storage for water quality control purposes is available only in the several proposed Federal projects, the largest of which is located downstream from the points of water need. After 1970, some water will be available in Aubrey Reservoir upstream of Dallas on an interim basis. The initial quantity is about 65 mgd (increased system yield) which will gradually decrease until it is all needed to meet municipal and industrial requirements.

An operation plan of surface water reservoirs in the basin was developed. The prime function of this plan is efficient utilization of available waters in maintaining water quality within the basin.

Basin Operations Plan to Maintain Water Quality

The most upstream significant pollution source in the basin is the city of Fort Worth. Other major sources are the Trinity River Authority plant and the city of Dallas in that order.

There is no water available for quality control in basin reservoirs upstream of Fort Worth. Therefore, the first stage of development to meet water quality requirements is a pipeline from Tennessee Colony Reservoir to Benbrook Reservoir by the year 1970 which will transport a yearly average of 80 mgd. This water is to be released from Benbrook Reservoir to satisfy monthly needs varying from 136 mgd in July to 29 mgd in January during the year 1970. Also to be constructed by this time is Aubrey Reservoir. Additional releases from this source amounting to an annual average of 40 mgd in 1970 are required to abate the pollution imposed by the city of Dallas. This first stage development will satisfy water quality needs in the upper basin until the year 1985.

Additional treatment to improve the oxygen economy in the effluents of the Fort Worth, Trinity River Authority, and Dallas waste treatment plants will be required by the year 1985. This additional treatment, coupled with 80 mgd of dilution water from Tennessee Colony Reservoir will be adequate to satisfy water quality needs in the upper Trinity River basin until the year 2020.

After the year 2020, the water from Tennessee Colony Reservoir will be needed to meet municipal and industrial requirements in the upper basin and should revert to this use completely by the year 2040. In all probability, waste treatment technology will have advanced sufficiently to negate the need for quality control water beyond the year 2020. The period of 20 years between 2020 and 2040 allows for stage construction of such facilities. On this premise, no needs for quality control water were projected beyond this year.

In the Houston area, continued disposal of wastes into the Buffalo Bayou watershed and the Houston ship channel, even when treated to remove 90 percent of the organic pollutants, will require average annual regulation flows approximating 1,200 mgd, and a maximum monthly flow in excess of 2,000 mgd in the year 2020. At present, there seems little likelihood that such flows could be made available.

An alternative which would be effective to the terminal year of the study, and probably beyond, would be the construction of one or a series of outfall lines to discharge treated wastes into the Gulf of Mexico at a suitable point offshore. Further studies of this nature are, however, beyond the scope of this report.

VIII. PLANS FOR SUPPLYING FUTURE WATER REQUIREMENTS

The projected study area water requirements to satisfy municipal, industrial, nonmunicipal, water quality control, navigation, and irrigation uses are 5,638 mgd by the year 2020 and 10,179 mgd by the year 2070. Similar requirements for the Trinity River basin, including exports, are 3,433 mgd and 5,187 mgd for the years 2020 and 2070, respectively. Existing, under construction, authorized, and proposed reservoirs in the Trinity River basin will yield 2,297 mgd, and reservoirs in the long-range plans of the remaining area will yield 1,461 mgd. An additional supply of 2,060 mgd would be required to satisfy study area requirements in the year 2020 and, similarly, 6,601 mgd additional would be required in the year 2070.

An analysis of the available ground water, return flow, and brackish water indicated that the potential of these resources may be sufficiently developed to meet the additional needs in the area to the year 2070. It is reasonable to assume that ground water use in the study area will expand beyond the present 339 mgd; that the use and reuse of return flows will progressively increase throughout the projection period; and that a considerable amount of brackish water will be used for industrial cooling along the gulf coast as the cost of fresh water supplies increases. Other than to conclusively establish the fact that ultimate water requirements will necessitate the maximum practical development of these water resources in the study area, no definitive basis is available to assign a schedule to their development. Generally, the development and use of these water resources will progress in accord with changing economic conditions and areal development of the study area and with distribution, availability, and quality of these water resources.

The water requirements and resources are summarized in Table VIII-1.

Table VIII-1

Summary Water Balance (All quantities in mgd)

Other a/		926	1,104	2,060		2,710	3,891	6,601
Supply		1,457	$\frac{1,101}{840} \frac{b}{b}$	3,578		1,457 180 <u>c</u> /	$\frac{1,101}{840} \frac{b}{b}$	3,578
Surface		In Basin Import	In Area Import	Total		In Basin Import	In Area Import	Total
ement	ear 2020	2,593	3,045	5,638	ear 2070	4,347	5,832	10,179
Requirement	For the Year 2020	In Basin	In Area	Total	For the Year 2070	In Basin	In Area	Total
Area		Trinity River Basin	Area Outside Trinity River Basin	Total Study Area		Trinity River Basin	Area Outside Trinity River Basin	Total Study Area

a/ Includes ground water, reuse and recirculation of return flows, and brackish water for industrial cooling in coastal areas.

In accordance with Texas Water Commission Permit No. 1970 from Livingston-Wallisville Reservoir system. 19

e/ From Lake Tawakoni (Iron Bridge) and Flat Creek Reservoirs.

IX. BENEFITS OF STORAGE

Evaluation Method

The report of the Sub-Committee on Evaluation Standards of the Federal Inter-Agency Committee on Water Resources makes the following comment on evaluation of municipal and industrial water supply:

"From an overall public viewpoint, a municipal and industrial water supply development will be economically justified if it provides water to meet expected needs at a cost not greater than the cost of the alternative source that would likely be utilized in the absence of the project."

The alternative cost method has been used for evaluation of all storage proposed in this report.

Costs

For purposes of comparison of alternatives, capital costs were converted to equivalent annual costs using an amortization period of 100 years and a non-Federal interest rate of 4 percent. The costs so determined for the date of first use of the project are discounted to their "present" value which in this report refers to the year 1970.

Alternative Plans

Six of the proposed reservoirs in the Trinity River basin are Federal projects. These are Lakeview Reservoir, Tennessee Colony Reservoir, Aubrey Reservoir, Roanoke Reservoir, Wallisville Reservoir, and the enlargement of Lavon Reservoir. Benefits attributable to the latter two projects are covered in earlier Public Health Service reports and are shown in Table IX-1.

Table IX-1

Benefits of Storage in Wallisville and Enlarged Lavon Reservoirs

Project	Yield (mgd)	Annual Benefits (\$)
Wallisville (Water Supply)	146.0	359,000
Lavon Enlargement (Water Supply)	42.7*	935,100

*Yields shown are increases resulting from reservoir enlargement.

The water supply plan reveals a need for all water that can be economically developed in the Trinity River basin. And investigations of water supply sources in surrounding basins indicate that there are no sources of suitable quality water available, other than those already included in the plan. Therefore, the alternatives to Lakeview, Aubrey, Roanoke, and Tennessee Colony Reservoirs are single-purpose reservoirs at the project sites.

A yield-requirement analysis determined a need for water quality and/or water supply storage in Lakeview, Tennessee Colony, and Aubrey Reservoirs by the year 1970. In addition, the Corps of Engineers has received adequate assurances from the city of Grand Prairie, Texas, and the Trinity River Authority committing the entire conservation yield of the Lakeview and Tennessee Colony Reservoirs and other features of the overall Trinity River basin development plan at the earliest possible date. Therefore, no discounting of the benefits calculated for these projects is made.

The benefit calculated for Roanoke Reservoir is discounted since the earliest need for storage at this site is the year 2000.

Benefits attributable to these projects are shown in Table IX-2.

Table IX-2

Benefits of Storage in Lakeview, Aubrey,
Roanoke, and Tennessee Colony Reservoirs

Project	Yield (mgd)	Annual Benefits (\$)
Lakeview (Water Supply Only)	28.4 <u>a</u> /	907,300
Aubrey (Water Supply and Quality Control)	65.3 <u>b</u> /	1,085,200
Roanoke (Water Supply Only)	23.9 <u>b</u> /	210,800 <u>c</u> /
Tennessee Colony (Water Supply and Quality Control)	290.8	5,589,600 <u>d</u> /

a/ Yield does not include 2.0 mgd utilized by the existing Mountain Creek Reservoir.

b/ Yields shown are increases in system yields based on storage exchange with Grapevine and Garza-Little Elm Reservoirs.

c/ Discounted 30 years from 2000 to 1970.

d/ Includes 84-inch pipeline and pumping facilities to provide 80 mgd of water for quality control upstream of Fort Worth.

The benefits of storage as shown above for Aubrey and Tennessee Colony Reservoirs must be divided between municipal and industrial and water quality control purposes in accordance with the portion of storage used for each as outlined in the water supply plan and water quality control sections of this report. Since this varies with time, it follows that the part of the total benefit attributable to each purpose also varies. Benefits shown in Table IX-3 were calculated in this way by decades until the total benefit becomes attributable to storage for municipal and industrial water supply purposes.

Table IX-3

Benefits of Storage for Municipal and Industrial
Water Supply and Water Quality Control Purposes in
Tennessee Colony and Aubrey Reservoirs

		Annual	Benefits (\$)	
	Tennesse	e Colony Res.	Aubr	ey Res.
	Yield:	290,8 mgd	Yield:	65.3 mgd
	M. & I.	Water	M. & I.	Water
	Water	Quality	Water	Quality
Year	Supply Supply	<u>Control</u>	Supply Supply	Control
1970	1,260,400	4,329,200	-0-	1,085,200
1980	1,260,400	4,329,200	65,100	1,020,100
1985			119,400	965,,800
1990	1,260,400	4,329,200	1,085,200	-0-
2000	1,260,400	4,329,200		
2010	1,260,400	4,329,200		
2020	1,260,400	4,329,200		
2030	3,657,800	1,931,800		
2040	5,589,600	-0-		